





A NEW
PHILOSOPHY OF MATTER.

A NEW

PHILOSOPHY OF MATTER,

SHOWING THE

IDENTITY OF ALL THE IMPONDERABLES

AND THE

INFLUENCE WHICH ELECTRICITY EXERTS OVER MATTER
IN PRODUCING ALL CHEMICAL CHANGES,
ALL MOTION AND REST.

BY
GEORGE BREWSTER.

New and Revised Edition.

WITH IMPORTANT ADDITIONS, CORRECTIONS, AND
AN EXTENSIVE APPENDIX UPON ELECTRICITY
AS A CURATIVE AGENT,

BY
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* Apparently in error.

See Brewster's *Electricity*, 1843, pp. 1-10, where it is given and this is a good copy.

INTRODUCTION.

THIS very interesting and highly instructive work, from the late Professor George Brewster, was written some thirty-one years ago. Although very much needed, for unavoidable reasons it has never been brought to view for the benefit of the world.

It was issued in book form, unbound, in 1843, at which * time the author suddenly died. For this reason, I suppose, it was never finished and circulated. In 1859 it was my good fortune to obtain a single copy of the work. By a careful perusal I found *great* as well as *new* and important truths on the sublime science in which I was *then*, and am still, deeply interested, namely, *Electricity*.

After much research, I found where it was printed some sixteen years before; but not having been called for by the author, all but a few copies had been used up for packing, or sold for waste paper. I obtained the price per copy, and immediately sent an order for the balance.

Occasionally I showed the work to my students under electrical instruction, who were inquiring for some textbook as reference. They were enthusiastic over its contents, and were ever anxious to possess themselves of a copy.

It was not long before I concluded, at some future day, to republish the work — there being such a desire to obtain

it by all who were privileged to see and read it. After waiting a reasonable time for it to appear by other hands, and realizing its intrinsic value to the world, I concluded to undertake it myself, together with a supplement embracing a synopsis of the processes of my new mode of electrical diagnosis and treatment of disease, which I have been urged to do by students and others, and not a few medical practitioners.

After my determination to republish the work, I refused to sell it to any one; but finally consented to part with a few copies to my students, who had read and re-read the copy at my office until they became enamored with its great value, so that they would not be denied, and cheerfully offered five dollars per copy. Some three or four years ago, or even more, perhaps, I commenced making preparations for republishing the work, with my appendix, and stopped selling any more copies — even refusing ten dollars per copy.

The original print was in unreadable type, on very poor paper, and with many corrections needed even in the proof.

The book, in the main, contained a rich mine of scientific wealth; but it needed many alterations before it could be circulated as a truly brilliant star in the canopy of science.

With these few introductory remarks, I submit it to the careful and candid perusal of all lovers of real science, especially as demonstrated by this wonderful and ever-present agent, *Electricity*.

A. H. STEVENS.

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A NEW PHILOSOPHY OF MATTER.

LECTURE I.

INTRODUCTORY TO A SERIES OF LECTURES ON THE IMPONDERABLE AGENTS.

THE present age is peculiarly and emphatically distinguished. — An important prophecy is in the very process of fulfilment. Many are “running to and fro,” and knowledge is more rapidly increasing than at any former period of the world. Acceleration marks the progress of everything. Instead of travelling, as formerly, at the snail-like pace of three or five miles per hour, we now dart away upon the wings of steam, at a rate varying from *fifteen* to *forty* miles per hour. And the progress of man in science keeps pace with his progress in locomotion. This is quite as much owing to the fact that “many run to and fro,” as to any other fact whatever. Individual acquisition in science is not so much hoarded as formerly. It is rather appropriated as common stock — rather scattered *broadcast* over the land.

There is another fact, which greatly accelerates the increase of knowledge. Scholars, at the present day, while following the direction of their inclination, and obeying the promptings of genius, confine their attention, more than formerly, to the thorough investigation of isolated branches of science, after having glanced, as in their collegiate course, at the whole routine of *general* knowledge. One concentrates every energy of his intellect to the minute examination of *one* subject, another to *another*, another to *another*, and so on. Each investigates that branch for which his mental habits and bias most peculiarly fit him. By such concentration, truths and facts in science are discovered, which would never have been discovered by roving from branch to branch, and aiming to become what is called *a universal genius*. Thus has light been poured with intense radiance upon what was dark, and errors in both theory and practice have been corrected.

But even such an individual concentration of mind would not greatly accelerate the increase of knowledge were not the results of such concentration communicated. This is done through the medium of oral instruction as well as printed, for this is emphatically the age of lectures. Thus the labor of acquiring and diffusing knowledge is divided among a large number, and, by such a division, a vast multitude of important scientific facts are brought forth to light, which had lain dormant and undiscovered for ages, and might still have remained dormant and undiscovered for ages more without the intervention of such agency.

The prevailing disposition of society is, also, auspi-

cious. There is an insatiable thirst for knowledge and novelty, and any one who can administer a palatable beverage to quench that thirst is favorably received, and enjoys generally such a share of patronage as to reward and stimulate his exertions.

Confident that this mental concentration to the investigation of isolated branches most effectually promotes the increase of knowledge, and that such an auspicious disposition prevails through intelligent society, I am induced to offer to the public a course of lectures upon a particular subject which I have investigated, with the assured conviction, however, that an author who publishes a book, or a lecturer who discourses upon a scientific or any other subject, should have *four prominent objects* in view :

- 1st. SOMETHING NEW.
- 2d. SOMETHING IMPORTANT.
- 3d. SOMETHING TRUE.
- 4th. SOMETHING INTELLIGIBLE.

The reasonableness and propriety of each of those objects will be apparent upon a moment's consideration.

1st. It should be one prominent aim of a writer or lecturer to produce *something new*, either by the discovery of latent facts, or the correction of untruths and false theories in science, or the systematic classification of facts long known, but long scattered in chaotic and useless confusion. For, to lecture or write upon any subject, without advancing new thoughts, or suggesting something which has not already been suggested by authors or by lecturers, seems to be "treading in the footsteps of our illustrious predecessors" to no very material advantage to

the world. This, I am aware, is often done. A very considerable number of books which, year after year, emanate from the press, and no small share of the lectures delivered upon the sciences, are nothing more nor less than the repetition of old ideas in a new garb to prevent the petty plagiarism from being too barefaced, and that garb, too, oftentimes made less elegant and less attractive than the original. Something higher than this should be the aim of a lecturer. No bold, independent and vigorous thinker — none but a mere intellectual parrot, would stoop to such servile imitation of others, when before him lies, spread out in endless perspective, a vast, unexplored, immeasurable wilderness of knowledge, which would give scope for ages upon ages, yea, for eternity itself, to the untamed energies of the most powerful intellect that men or angels ever saw.

But it must be acknowledged that the fortune of him who has thus forsaken the beaten path of generations, and has aimed at *originality*, has not often been an enviable one. Such an one has frequently ascertained, by bitter experience, how hard it was to “climb the steep, where Fame’s proud temple shines afar.” He has often found that the untrodden course which he has marked out for himself has been anything but a flowery path. Briars and thorns have grown thickly there. In it he has encountered the chilling blasts of poverty — the discouraging dissuasions of friends — oftentimes a concentrated and malicious chorus of serpent hisses from enemies, and has been pointed at with the finger of scorn, as a poor, crazy enthusiast, or a visionary builder of air-castles.

This conclusion will be irresistibly forced upon the mind of any one who carefully consults the records of the past. When the celebrated William Wirt remarked, with regard to the perils of innovation, "*Woe betide the hand that plucks the wizard beard of hoary error,*" — he was doubtless looking at the history of bygone time. Men used to regard the slightest encroachment upon established laws in *politics*, *religion* and *science*, how glaringly erroneous-soever those laws might have been, as reckless and wicked foolhardiness. Facts in abundance prove this. A Columbus, a Newton, and a Fulton might promulgate new theories of the utmost importance, and sustain and defend them with argument piled upon argument mountain-high — with argument upon argument, too, the most rational, conclusive and convincing, and they would invariably fail for a long time to convince. Prejudice, like an ancient mail-coat of steel, enclosed the mind, and warded off the shafts of conviction. Many men, and even men reputed to be scientific, would obstinately persist in scepticism, until actually *forced* to believe, by the *common sense* and the *common* opinion of the world around them — until the truth of rejected theories would blaze upon that scepticism with such overpowering intensity as to consume it, and make those who harbored it either ashamed of their extreme dulness of apprehension, or else of their dogged obstinacy.

The days of such prejudice and scepticism are, however, evidently passing away. It is true that men are cautious how they give a ready credence to novelties in theory or in practice, but, as a general thing,

perhaps not too cautious. * A certain watchfulness is doubtless necessary for the safeguard of the bulwarks of truth from sacrilegious and ruthless innovation. But further than this, incredulity at the present day scarcely goes. So rapid, so surprising and so successful have been and are still the improvements and discoveries of the age, that puzzled scepticism stands confounded and amazed, not knowing what to *say* or scarcely what to *think*. A very great change has come over the opinions and feelings of the world. Theories in science may now be promulgated, which discredit all preconceived sentiments upon the subject at issue, and explode them, and still they will receive a candid and respectful hearing from an intelligent community — and if they happen to be supported by even the *plausibility* of argument, that thinking community will not reject, even if it do not embrace them. There will only be a suspension of judgment for *more light*. *This is wisdom*. By such a course of policy, truth in science is sure to triumph, and error to be overthrown and discredited, however subtly interwoven with the maxims and policies of society, and however supported by the authority of great names.

2d. It should be another prominent object of an author or lecturer to suggest *something important*. For it should ever be kept in recollection, that “all is not gold that shines,” and that, although “variety is the spice of life,” yet that which is *new* is not always *important* or *valuable*. Ideas may have originality, and yet, at the same time, they may be either as simple as the babbling and nonsense of mere idiocy, or as unreal as the wildest and most incoherent ravings

of stark madness — the likeness of nothing in the heaven above, or in the earth beneath, or within the whole wide regions of sober thought. Matter then, worthy of the attention of intelligent society, must not only be *novel*, but *important*.

3d. Another prominent object of an author or lecturer should be to promulgate *something true*. For ideas may be both *novel* and *important*, and yet, if they are incorrect — if they lack the very essential support of incontrovertible fact, they are unworthy of credence. Without this, a theory may be both beautiful and grand, but must be as evanescent as it is beautiful, and as substantial as it is grand.

The example of Sir Isaac Newton is well worthy of the attention of scholars and authors. His discriminating intellect promptly and invariably rejected every theory and every proposition, however plausible, which had not the firm and imperishable basis of fact and conclusive demonstration. He jumped at no conclusion, but came to it step by step, through the path of clear, patient, and logical deduction. Away from his presence, he sternly rebuked everything like surmise and conjecture, and gave no audience for a moment to anything which bore not the characteristic features of scientific truth. In this respect, imitation of him would not be reprehensible. It would rather be a mark of wisdom.

But 4th — to cap the climax, an author or lecturer should aim to promulgate *something intelligible*. This is quite as indispensable as anything else. For thoughts may be *novel* and *important*, and have enstamped upon them the characteristics of immutable

truth, and yet, if they be not expressed so as to be *intelligible*, they might just as well not be expressed at all. The professed object of all language, either oral or written, is to convey ideas to the minds of those to whom it is addressed. But language which is not understood accomplishes not the object for which it was invented, or, if it be understood by only *one* tenth, then *nine* tenths are excluded from its benefits, just as much as if they were required to decipher the meaning of the obsolete Egyptian hieroglyphics.

Now if an author or a lecturer have ideas to communicate, which seem to be sufficiently *novel*, *important* and *true* to warrant their promulgation, what should he do? Should he adapt his remarks exclusively to the taste and the comprehension of the few, who can emphatically be called the *literati*? Should he discourse learnedly in that technical phraseology, which, either from an imagined convenience, or else from the impulses of pedantic vanity, has been invented for the sciences, and which is as little understood by the mass of readers as if those sciences were clothed in the dialect of one of the dead languages? Should he be ambitious to throw an air of mysterious profundity and scientific dignity around his remarks, or should he be mainly solicitous to be understood by all, and to adapt his language to the capacities of all of moderate attainments, either by avoiding *altogether* the use of blind and fresh-coined technical terms, or else by fully explaining those which the imperious dictate of custom has made necessary and indispensable? There can be but one opinion upon this subject. The universal sentiment would doubtless be in

favor of plainness. Aim to be understood, instead of displaying ostentation, would be the dictate of common sense. This can be done without sacrificing a proper dignity of expression or condescending either to a vulgar coarseness and rudeness of language, or a low and childish puerility of remark. It can be done, too, without offending the taste even of the most fastidious among the scientific, or forfeiting the approbation of those who combine a commendable public spirit with extensive acquirements, and who wish to see knowledge widely disseminated among the mass.

Those four prominent objects, which have been thus considered separately, and which should be those of every author or lecturer, will be the landmarks by which I purpose to be guided in a proposed series of lectures upon the imponderable agents of chemistry. It is my purpose that they shall contain *novelty, importance, truth*, and be made, if possible, *intelligible*.

Floating through books and periodicals, various indefinite surmises or conjectures, respecting the subjects which I purpose to discuss, are to be found scattered here and there, but all confused. Nothing is systematized or affirmed with positive confidence and certainty, or supported with a proper array of facts and arguments, except in a single instance, in that almost unknown, but yet invaluable scientific jewel — Dr. Metcalf's "New Theory of Terrestrial Magnetism," published in 1833, in which he assumes and *proves*, by logical demonstrations which cannot be successfully controverted, that *Caloric* is *Electricity*. After having written and lectured upon this subject in Baltimore and other places in 1838, I was

avored by a friend with the perusal of this work, and was agreeably surprised to find a perfect coincidence between our views, so far as *caloric* is concerned. By subsequent investigations I have come to the conclusion that not only *caloric*, but that all the other imponderables are one and the same agent—that Electricity, Galvanism, Magnetism, Light, Caloric, Gravitation, the Attraction of Cohesion, Capillary Attraction, and Chemical Attraction are only different modifications of the same essential principle.

If this be true, as I hope, by facts and arguments to prove, then there is an entirely new and unexplored field opened before the student in chemistry and natural philosophy. By it, many things will be exploded as false, which have heretofore been taught in the schools as scientific truths, and many things will be systematized and simplified which have been complicated, confused, and unintelligible. It seems to lead directly to the adoption of this one broad and comprehensive proposition—the basis or substratum of all knowledge.

There are, of the productions of creative power, three distinct essences, or essential principles in the universe, and BUT three, and everything created and finite, of which we either have or can have any conception, whether it be animate or inanimate—physical, animal, or intellectual, can be referred to one or the other of these three essential principles, as to its native, legitimate, proper basis or substratum.

This proposition, it will be seen, embraces within its comprehensive scope the whole illimitable domain of science, both visible and invisible. Sceptics in the

republic of letters, or old-fashioned book-worms, who regard the slightest encroachment upon what they may have read, as sacrilege, will doubtless call this proposition sweeping and chimerical. But sweeping and chimerical as it may, however, seem to them or to others, it is believed, nevertheless, to be capable of satisfactory and even perfectly conclusive and logical demonstration, as will be shown hereafter.

The names of those three fundamental principles we will here give in their natural order, together with a concise definition of their properties.

The first we shall call *Ponderable Matter*, it being the same technical epithet which is used in standard works. By this term we include all those substances of every name and form which are tangible — which can be noticed or appreciated by most of the senses by which we acquire ideas of external objects — which are measurable, and which have magnitude and weight.

The properties or qualities of this first essential principle of the created universe we consider to be perfect inertness and inherent dormancy, meaning by those terms, that a substance under their influence has no activity or disposition to activity in itself — that it has therefore no power of changing itself, or of communicating motion to itself, either by component parts, or in the aggregate or whole — that it would, therefore, remain forever changeless, as when left at creation, and forever unvaried by modification, a cold, motionless mass of inertia or sluggishness, unless operated upon by foreign agencies, sufficiently powerful to overcome that inherent disposition to remain forever sluggish and unmoved.

The second essential principle embraced in our proposition we shall call *Imponderable Matter*, it being, also, the same technical epithet by which it is designated in the text-books. By this term I include Electricity, Galvanism, Magnetism, Light, Heat or Caloric, Gravitation, the Attraction of Cohesion, Capillary Attraction and Chemical Attraction. These are all, in their nature, alike intangible. That is, they cannot be handled so as to be examined like ponderable substances of the first class. They are inappreciable by most of the senses, immeasurable, and have no perceptible magnitude or weight.

This *imponderable principle* is entirely distinct and different from ponderable matter, not derivable from it, but perfectly independent of it, and yet having such a natural affinity for it, by the inscrutable attraction of opposites, which seems to be an immutable law of nature, as to pervade it completely. Not a single particle of ponderable matter is there in creation — not an atom borne on the atmosphere — not a single mote floating in the sunbeam, but what is attended by its appropriate share of the imponderable principle, when all the elements are in equilibrium.

This wonderful and mysterious agent is extremely subtle — so subtle that it is invisible and imperceptible, except when condensed into the electric spark, or accumulated by the galvanic battery, or poured down upon us in the light of day, or gathered into focal intensity by the lens or burning-glass, or exploded in the thunderbolt of the clouds, or collected together into that capacious reservoir of electric fire — *the sun*. Elasticity unbounded is one of its char-

acteristics, and its activity is inherent and more restless than the ocean wave, it being always in motion, for, if the balance of the elements be disturbed at all, and there be, anywhere in creation, a partial vacuum, or an abstraction of the subtle fluid, so far as to make that spot *minus* with regard to surrounding regions, it rushes in with irresistible velocity, and restores that disturbed balance. Rapidity inconceivable characterizes its movements. If impeded in the slightest degree in its everlasting career, and accumulated and restrained by appropriate exciting causes, it exhibits a fearful energy — an energy perfectly overwhelming, and bursts its bands with infinitely greater ease than did the unshorn Samson.

It is that agent, independent of ponderable matter, at which we have already hinted, which pervades it omnipresently, according to certain definite laws, which will hereafter be explained, having a natural affinity for it, and possessing inherent power sufficient to overcome its inertia or sluggishness, to work all the chemical changes and produce all the motions in it, whether on the scale of atoms, or of worlds, or of constellations of worlds. It, in fact, seems to be the very representative of Deity himself, expressly appointed and commissioned to produce the multi-form and almost countless transformations of matter — all the chemical changes of decomposition and re-composition, which are constantly progressing around us and throughout nature, and, by its inherent energy, and the activity which it imparts, to keep up the motions of the universe of material systems, and to invigorate both the animal and vegetable life, in its

myriad forms, with which those systems are furnished.

Some materialist may here draw the confident conclusion from what I have asserted, that imponderable matter is *mind*, and that it is the *only Deity in the universe*. No such conclusion, however, results necessarily from the premises. Instead of favoring the doctrine of materialism in the slightest degree, I pledge myself to be prepared to show in its proper place in the series of lectures, that from *this source* alone can be drawn the most powerful and convincing arguments which can possibly be drawn from nature to overthrow that doctrine. I am not one of those who tremble to acknowledge an undeniable fact, lest that fact should seem, forsooth, to militate against my creed. The God of nature never would have created an agent, or have established a law, which, when *discovered*, and fully *understood*, would militate against his divinity, or undeify himself in the estimation of a *sound philosopher*. We must never deny the evidence of our senses, and discredit incontrovertible facts, lest, peradventure, our *belief* should be overthrown by them, but should endeavor, by ingenuous and candid investigation, to ascertain *how they can be reconciled with our belief*.

We now come, naturally, to the *third* essential principle of the created universe, which we denominate *mind*. Pure ethereality seems to be its constituent property, which term, we think, will correctly define its nature, if, in the acknowledged vagueness, looseness, and imperfection of language, all shall attach to it an appropriate signification. The intellect is no

more a substance or the emanation of a substance, than thought or a train of thought is substance. As the emanations and exhalations, or the minute particles flying off from matter are matter *also*, so mind is, and, of necessity, *must* be, in the inherent fitness of things, of the same nature of its exhalations, which we know are *thought, intelligence, moral feeling, and volition* — properties which may be truly said to be *something* or *realities*, though there be no *materiality* about them. Who, for instance, would affirm that an *idea* is matter? Has it length, breadth and thickness, either perceptible or imperceptible, as have all the particles of matter, either ponderable or imponderable, how minute soever they may be? To attempt seriously to disprove such a proposition would be too much like battling, with Quixotic valiancy, the unsubstantial shadows which chase each other over the landscape. Such an attempt would sufficiently establish a man's claim to the diploma of a confirmed Bedlamite, and would entitle him, beyond all controversy, to a straight-jacket, and an introduction to the benevolent hospitalities of a mad-house. Such a proposition is too preposterously absurd for a single moment's belief. The influence which the intellect, or its controlling power, the will, exerts over the other two fundamental principles of creation, entirely precludes such a belief. For, as the imponderable principle controls the ponderable, so *mind* controls both the *one* and the *other*.

The intellect, or will of the carpenter, for instance, controls the muscles of his physical frame, through the action of the nervous fluid or animal electricity

upon those muscles, and, by the strength and motions of his physical frame, so controlled, the edifice is constructed, and the grand, the beautiful, and the symmetrical in architecture are made to adorn the dome, the temple, and the various other fabrications of the mechanic arts.

The imponderable principle is, also, subject directly to the volition of intellect, although it has no guiding will of its own.

A Franklin, for instance, could extract the subtle fires from the storm-cloud, as it passed over head, with his electrical kite, and conduct the red and crashing bolt harmless to the earth by his lightning-rod.

Galvani and his successors could extract the same fiery fluid from a certain association of zinc, copper and the acids, in a stream strong enough to burn iron like tinder.

So we have seen that there are *three* created principles in the universe, each entirely diverse from the others, the first being under the control of the second, and both the first and second under the control of the third, as will be conclusively demonstrated in that part of the following lectures in which the philosophy of *Animal Magnetism* will be investigated.

There is, in the universe, still another principle,—if it be right to call the same a principle—which I have not included in my classification, because it comes not within the list of created substances. Its attributes are Omniscience, Omnipresence, Omnipotence and Eternity, as they must, of necessity be, in the very inherent nature and fitness of things, if uncreated or

self-existent, for an uncreated agent could not possibly be otherwise than infinite.

This self-existent, eternal principle we call Deity. Beyond Him we hold that there can be nothing either created or uncreated, finite or infinite. He embraces and controls and pervades and governs everything. As electricity governs inert matter, and created mind governs both, in a certain sense, so this fourth mysterious, incomprehensible, all-pervading Essence gives immutable, irresistible laws to the whole three in an *unlimited* sense, and does precisely what he *wills* throughout the whole *illimitable* vastness of both *duration* and *space*.

In proof of the positions which I have, in a measure, assumed, without having defended them with illustration and argument in the present lecture, the following work will consist of *thirteen lectures more*, in which it will be my object to investigate minutely the properties, laws, and peculiar agencies of the three essential principles of creation, together with an occasional allusion to the uncreated fourth, or the Supreme Architect. And I design, also, as definitely as possible, to show the relationship which exists between those three essential principles.

The first subject of investigation will be *common electricity*. I shall show *how* it was discovered, what are the immutable laws by which it is ever governed, and what are the manifold and powerful agencies or influences which it exerts over matter, in the production of all chemical changes and all chemical analyses.

I shall then investigate, in their appropriate order,

the other imponderables, viz.: Galvanism, Magnetism, Light, Heat or Caloric, Gravitation, the Attraction of Cohesion, Capillary Attraction, Chemical Attraction, and Animal Magnetism, and show that they are governed by precisely the same laws as common electricity, that they exert the self-same influences over inert matter, and that they are, therefore, the same individual agent, though known by a variety of names, and exhibited under a variety of modifications.

During the course of this investigation, I shall endeavor to show that the sun is the grand reservoir of electricity — the great galvanic battery of the solar system — that its influence over the planets is *electric* — that their motions, both diurnal and annual, are produced by that influence, in accordance with those electrical laws of attraction and repulsion which can be tested in the laboratory upon little pith balls — that the attraction of gravitation, as well as that of cohesion, is caused by the light and caloric of the sun, in their operation upon the material of the earth, in constituting it a magnet — that terrestrial magnetism and the north and south polarity of the earth, which attract and guide the needle of the mariner's compass, are produced by the same cause; that the reason why the needle points to the north and south, rather than to the east and west, is because electricity, it is now well known, influences and guides it, and because those streams of caloric or solar heat, which, in obedience to an immutable law of nature, run continually from the equatorial regions to the point of greatest cold in the polar regions, is *that same electricity* — that that point of maximum cold is proven, by the obser-

vations of navigators, in their voyages of exploration in the high latitudes of the Arctic and Antarctic seas, to be the magnetic pole of the earth both north and south, which varies from the geographic pole, in some seasons fifteen degrees or more—that the Aurora Borealis and Aurora Australis, or Northern and Southern Lights, stream up from these points of greatest cold, or the magnetic poles of the earth, and are, therefore, the electricity or caloric that runs continually from the equator to those magnetic poles, and there passes outward and upward, into the rarer regions of the atmosphere in its circuit, and forms precisely the same lambent, nebulous, waving appearance which electricity exhibits when passing through an exhausted glass tube, or any other exhausted medium.

I shall endeavor, also, to demonstrate, by conclusive proof, that it is the vivifying principle of both animal and vegetable life, and, as far as possible, in a science as abstruse as this, to show *how* it operates—that it is the active efficient agent of both the decomposition and the recomposition of the organic structure of men and animals, which is continually going on—that its application in cases of disease, by those who understand thoroughly its laws and chemical agencies, is of invaluable consequence, whether it be by machinery or by animal magnetism, and that by its scientific and proper application, it can be made to cure epilepsies, apoplexies, palsies, rheumatism, fever and ague, and, indeed, almost every other disease that “flesh is heir to,” except old age, and both *how* and *why*, in most cases, it can be done—that it can

be done by known and tested chemical agencies, in strict accordance with immutable chemical law.

And, finally, I will endeavor to show what influence mind has over this subtle agent, in producing the motions of the human body, and wherein that influence is different from the choice or instinct, which controls the motions of brutes, by which I shall prove that animal magnetism, so far from being a "*miserable humbug*," is a sublime science, which can be sustained by as many incontestable proofs as any science under heaven — proofs, too, which, if any man would seriously doubt, he must first doubt the evidence of his own senses, or his own personal identity.

I shall also show that animal magnetism, so far from having a tendency, as some suppose, to bring the truths of our holy religion into disrepute and discredit, lends a most efficient and powerful aid to sustain them, and, rightly considered, must lead every candid mind to the conclusion, that we are, in truth, "*fearfully and wonderfully made*."

In the discussion of those subjects, it will be perceived, by a perusal of the following pages, that I have, in many parts, adopted the argumentative style, based upon a few choice facts, selected from a mass that might have been collocated and inserted, and that, in some places, the thread of argumentation is drawn out somewhat attenuated.

This has been done *purposely*, from the fact that I was aware that many, and indeed almost all of the most important positions taken, were *novel*, and needed, of consequence, to be defended, at every apparently assailable point, from the attacks of prejudice.

After having spread these views, however, before the public, in this manner, it is my intention, when the novelty of the theory shall have worn off, and critics shall have exhausted their quiver, and fired at it their last shaft, and it shall, perhaps, have gained here and there a solitary advocate, to prepare, out of the substance of the materials here furnished, a class-book for schools, adapted to the present improved state of chemistry and philosophy.

C

LECTURE II.

COMMON ELECTRICITY.

THE subject of the present lecture is *Common Electricity*. I distinguish it by the epithet of "*common*," not because there is any *essential* difference between it and galvanism or its other modifications, but because the phenomena which we shall investigate in the present lecture are those which have been the longest and the most universally known, and, with the manifestations of which, all are more or less familiar.

This subject we intend to examine critically and very minutely, for upon it is based an important science, and, in order to understand that science thoroughly, we must thoroughly investigate its elementary principles. By the unerring test of experiment, we shall, upon a small scale, within the immediate purview of the senses, determine the laws and the agencies by which it is ever governed. Having ascertained these with satisfactory certainty, they will serve the valuable purpose of a chart, a compass and a pilot, as it were, upon the broad and interminable ocean of investigation, far from the sight of land. Yes, with these valuable auxiliaries, we can enter the vast laboratory of nature, and show how, upon a large scale, the planets are wheeled upon their axes, and impelled in their mystic dance around the sun,

by the self-same force that attracts and repels pith balls. For no one will dispute the fact, that the aggregate or whole is governed by the very same laws and agencies by which the individual parts and particles of that whole are governed. This proposition will be found to be unerringly true, apply it *where* you may, and as *extensively* as you may. The law by which an atom gravitates, or several atoms cohere or cling together, is the law precisely by which worlds gravitate and cohere. The laws by which a drop of water is held in a globulous state are the same precisely which hold the ocean together. There is no deception in nature. She is no coquette. She speaks the language of uniformity and consistency throughout her wide dominions, and you will never find her conduct, at one time, or in one respect, at variance with her conduct in another. Having ascertained a fact or law in physics, beyond the possibility of mistake or the shadow of a doubt, other facts and other laws, bearing a relation to the same thing, will, when discovered, uniformly and universally sustain the first fact or law. This admirable certainty and uniformity in the operations of nature enable astronomers to foretell eclipses for years before their occurrence with confidence, and to the definiteness of a single moment, to predict the transits of Venus, and give almost the precise data, even, for the flight and return of the eccentric comet.

Electricity was first detected or discovered in a substance called, in English, amber, which substance in the original Greek was called *electron* from which the term *electricity* is derived. This word *electron* is also

derived from *electore*, another Greek word, which signifies, *the beaming sun*, and, if it does not indicate that the ancients supposed the sun to be the fountain of this subtle fluid, it at least develops a remarkable accidental coincidence.

Thales, a celebrated Grecian of the city of Miletus in Ionia, who lived 600 years before the Christian era, and who was the contemporary of Pythagoras, is reputed to be the discoverer of this remarkable property of amber. He ascertained, probably by accident, that when rubbed, it acquired the power of attracting to itself certain light bodies in its immediate vicinity. For the want of amber, the student can illustrate the phenomenon with a stick of sealing-wax.

Familiarity with facts should never be suffered to lessen their interest, nor should we overlook the simplest truths, for a thorough knowledge of those simplest truths often leads to the discovery of the grandest and most sublime, while he that despises the day of small things, will, probably, never live to see the day of large things. The most magnificent results often thus originate. The dim dawning of the morning precedes the blaze of the meridian. The diminutive acorn springs up and becomes an oak, monarch of the forest. The majestic Amazon first issues as a little rill on the eastern declivity of the Andes. A neglected spark kindles a conflagration, and millions of wealth are lost in ashes. So with a thousand other facts. Their origin is simple, but their results are grand.

As the sealing-wax before being rubbed is passed over little bits of paper prepared for the purpose, they

are perfectly quiescent. Both are in a state of natural equilibrium or balance. Having excited it, however, by friction, it immediately exhibits a singular power unknown to it before. In this little experiment, trifling and simple as it may appear, there are treasured up volumes of wonder and inscrutable mystery, enough to puzzle for ages the clear-sighted penetration of a Newton himself. What is it that first diffuses over those bits of paper a tremulous quiver, then sets them upright, as if alive, and then makes them leap up, as if either in affection or in anger, to the cause of their momentary animation? Echo only answers: "What is it?" The chemist is puzzled and silent, the books answer not, and no one can tell. The influence of the charmed sealing-wax over those bits of paper is beyond the comprehension of the most gigantic intellect. All that can be known is that it is *electricity*, and that its operations are guided by certain fixed and immutable laws.

No wonder Thales stood in astonishment, when he made the discovery. No wonder he thought the amber animated with a principle of vitality. The emotions of the mind, when a grand fundamental or elementary truth first breaks upon it, are unutterable, and cannot be apprehended by the dull phlegmatic, who always plods along in the beaten path of his grandfathers. Such emotions often find vent in exclamations similar to those of Archimedes in Greek, when he had discovered the solution of a difficult problem, upon which he had been long and intensely studying. In ecstasy he exclaimed: "*Eureka! eureka!*" — "*I have found it! I have found it!*"

Before proceeding, it may be proper to remark that Thales was no ordinary man. "Like most of the ancient Grecian sages, he travelled into Egypt, lived in that country several years, contracted friendships with the priests, then the depositaries of science, became deeply skilled in all their mysteries and learning, and, returning to his own country deeply stored with the knowledge of the East, he ranked as the first of the seven wise men of Greece, and became the founder of the Ionic school." Apuleius, an eloquent writer of the second century, thus speaks of him :

"Thales, the Milesian, was decidedly the most eminent of the seven famous sages ; for he was the first inventor of geometry among the Greeks, the most judicious inquirer into the causes or nature of things, the most skilful observer of the stars ; he made great discoveries by small geometrical lines, in the regulation of times and seasons, the theory of the winds, the course of the stars, the *wonderful causes of thunder*, the oblique motions of the planets, the revolution of the sun, and the reason of the increase, decrease and eclipse of the moon."

From the time of Thales to that of Theophrastus, a disciple of Aristotle, who lived between two and three centuries after him, no new discoveries were made in electricity, which is somewhat surprising, since it is no local or occasional agent, but coeval with time, pervading all substances omnipresently, and being the palpable cause of some of the grandest scenes in nature.

In a work of Theophrastus, entitled in Greek, "*Peri*

Lithone," he ascribes the same property which Thales discovered in *electron* to the lapis lyncurius, the substance now called tourmaline. "It possesses," says he, "an attractive power, like amber, and, as they say, attracts not only straws and leaves, but copper also and iron, if in small particles."

From the period of Theophrastus, no allusion is made by authors, for more than two thousand years, to any but the discoveries already noticed, and therefore more than twenty-three centuries elapsed from the observations of Thales, before any material addition was made to the stock of electrical knowledge. Since that, for the last two centuries, its accumulations have been vastly more rapid and increasingly important.

In 1600, William Gilbert, physician to King James I., in a Latin work entitled "*De Magnete, magnetesque corporibus*," gives a description, towards its close, of a great variety of electrical experiments, entirely new.

A fresh impulse appears to have been given, during this century, to the study of electricity, by the discovery of the phenomena of magnetism, as it seemed in some respects to possess properties similar to the loadstone.

By his experiments, Dr. Gilbert added largely to the meagre list of electrical substances. He ascertained that diamonds, sapphires, carbuncles, iris, opals, amethysts, beryl, crystal, bristol-stones, sulphur, mastic, hard wax, hard rosin, arsenic, sal-gem, rock-alum, common glass, and stibium, or glass of antimony, have the power, when excited, to attract light bodies, and that this influence is not only ex-

erted over leaves and straw, but, indeed, over all matter, which is not extremely rare. He also ascertained that friction was necessary to produce electrical phenomena, that it was most potential when light and quick, and that electrics could be most strongly and permanently excited when the air was dry and the wind north or east.

For the want of suitable apparatus, this philosopher encountered many obstacles, as did all the rest of the early investigators of the science. His experiments were principally made with long, thin pieces of metal, and other substances freely suspended on their centres, to the extremities of which he presented the electrics he had excited.

Thirty years after the publication of "*De Magnete, magnetesque corporibus*," the celebrated Sir Kenelm Digby, in his "Treatise Concerning the Nature of Bodies," expresses the following singular notions respecting the influences of electricity :

"Attraction," says he, "is made by an attenuated emanation or a continuous effluvium, which, after some distance, retracteth into itself, as is observable in drops of syrups, oils, &c., which, spun at length, retire to their dimensions. Now these effluvia, advancing from the body of the electric, in their return do carry back the bodies whereon they have laid hold within the sphere or circle of their continuities; and these they do not only attract, but, with their viscous arms, hold fast a good while after, and if any shall wonder why these effluvia, issuing forth, impel and protrude not the straw before they can bring it back, it is because the effluvium, passing out in a smaller

thread and more enlengthened filament, stirreth not the bodies interposed, but returning into its original, falls into a closer substance and carrieth them back into itself."

Such fanciful hypotheses may be amusing, and exhibit an inventive ideality, but should never be indulged by a philosopher, in the form of positive assertions, unattended by positive proof, as in the quotation just made. They advance not true knowledge, but rather becloud and bedim it.

The learned Mr. Boyle, by his investigations towards the close of the seventeenth century, enlarged the catalogue of electrics somewhat, and ascertained, by his experiments, that the electrical properties of bodies are increased by wiping and warming them, before they are rubbed. Bodies of all kinds he supposed were attracted indiscriminately, and that this attraction took place in a vacuum as well as in the open air.

To this time philosophers had supposed that electricity possessed only an attractive power. For Dr. Gilbert, in his "*De Magnete, magnetisque corporibus*," remarked that magnetism possesses both an attractive and a repulsive power, but that electricity possesses the latter but not the former. Boyle, however; approached so far towards the discovery of repulsion, that he remarked that feathers and other light bodies would cling to his fingers after they had been attracted by electrics.

Otto Guericke, who lived contemporary with Mr. Boyle, and who is famed for his invention of the air-pump, made still further discoveries and improvements.

He made use of a sulphur globe, whirled on an axis much in the same way as our present glass globes. By this apparatus he could accumulate a greater amount of electricity than had hitherto been accumulated, and was, therefore, enabled to experiment with greater success and certainty than his predecessors. To him is due the honor of making the first full and satisfactory discovery of electric repulsion. "A body once attracted," says he, "by an excited electric, is repelled by it, and not attracted again until it has touched some other body." He kept a feather for a long time suspended in the air above his sulphur globe, and made also the remarkable discovery that, when repelled by an excited body, it always keeps the same face towards that body, as the moon does towards the earth.

Both Mr. Boyle^e and Otto Guericke discovered the electric light simultaneously, the one, as he supposed, in the diamond, and the other in his excited globe.

Dr. Wall about the same time discovered it in a still more satisfactory manner, which I will give in his own words :

"I found," says he, "upon swiftly drawing a well-polished piece of amber in the dark, through a piece of woollen cloth, and squeezing it pretty hard with my hand a prodigious number of little cracklings were heard, and every one of them produced a flash of light, but when the amber was drawn gently and slightly through the cloth, it produced only a light, but no crackling ; but by holding one's finger at a little distance from the amber, a large crackling is produced, with a great flash of light succeeding it, and, what to

me is very surprising, upon its eruption it strikes the finger very sensibly, wheresoever applied, with a push or a puff like wind. This light and crackling seems, in some respects, to represent thunder and lightning."

Sir Isaac Newton next made the discovery of a fact, which has often been disputed, but which is very necessary in establishing the theory which I assume, that both electric attraction and repulsion will penetrate through glass.

Mr. Hawkesby, next in chronological order, wrote, in 1709, a treatise on electricity, in which he published a variety of new facts with regard to attraction and repulsion, and the nature of electric light, supposing it to be phosphoric. Others who first observed it at this period adopted the same opinion.

About twenty years after, when the excitement produced among scholars by Newton's wonderful discoveries in Natural Philosophy had, in a measure, subsided, Mr. Grey turned his attention to the subject of electricity, and by him was discovered the *distinction* which exists between electrics and non-electrics, forming a new era in the history of the science. But as a detailed account of the interesting experiments which he made and published in the "Philosophical Transactions" for 1729 would be altogether too voluminous for the circumscribed limits of the present lecture, I shall simply allude to the fact, and pass on to the consideration of other important topics and experiments.

Thus far I have glanced rapidly, and in as brief a manner as I well could, at the history of the rise and progress of this science, and less than this I could not

well have done, consistent with a thorough examination of the subject. And what is the sum of our investigations thus far? It is this :

Amber and a great variety of other substances are capable of exhibiting electrical phenomena. Friction is, generally speaking, the cause of the exhibition of such phenomena. When they are made by friction to exhibit those appearances, they are said to be electrified or electrically excited, and the power of attraction which they then exhibit over contiguous light bodies is denominated electrical attraction.

But this is not the only power manifested, or the only influence exerted, by this agent over bodies or in conjunction with their own properties. There is a *repulsive* as well as an *attractive* force. This attraction and repulsion depend, as will be seen, upon the different electrical states of different bodies.

For illustration, rub a glass tube : it becomes electrically excited. Hold it over little bits of paper : they are attracted towards it from some distance, and with considerable force. But you perceive that the moment they come in contact they receive a portion of the electricity which attracted them, and are immediately repelled. Dropping, however, upon some other substance, they impart to that substance a portion of the electricity which they received from the glass, and are again attracted towards it, though with less force than before, because it is less excited than before, having in the first contact lost a portion of its superabundant electricity. This alternate attraction and repulsion continues, though more and more feebly, until the excited substance has lost entirely its

electric charge, and has returned to its natural state. It then exhibits no attractive powers whatever. Contiguous light bodies, however light and easily moved, remain perfectly unaffected and quiescent at its approach.

Another piece of apparatus, by which attraction and repulsion are still more forcibly and amusingly illustrated, is what is called the apparatus for the dancing-figures, by which pieces of paper, or images cut from pasteboard, or the pith of elder, are made to dance between two plates by the action and reaction of positive and negative electricities.

How wonderful the agency here exhibited! Who does not look with astonishment upon the mock creative and life-giving energy which electricity displays? Had some chemist made an exhibition like this in the dark ages, without explanation, or even in the days of Salem witchcraft, it would have rung throughout the country that he had made a league with the evil one, and he would, as a compensation for his wisdom and wit, have stood a pretty good chance to get a roasting for a wizard. There is a case on record directly in point. John Faust, an ingenious German, by the invention of types was enabled, during the dark ages, not only to publish books much faster, but also much *cheaper* than before. This newly-discovered art he kept secret for a time, and hence originated the nursery legend of *Dr. Faustus and the Devil*, in which he is represented as calling to his aid unlawfully the spirit of darkness.

There are many substances — all the metals in particular — which do not seem to be capable of being

electrically excited by friction. The reason, however, is obvious. They give a free passage over their surface to the electricity as it is excited, and it is instantly dissipated without being accumulated in any perceptible quantity.

These are denominated non-electrics, from the fact that they are not capable of being excited like glass and the resins. They are also called conductors, from the fact that they readily transmit the subtle agent without accumulation upon their surface. But it is *only* because they are good conductors that they happen to be non-electrics. Let them be insulated — that is, let them be placed upon some electric or non-conductor, such as glass or gum-lac, and they immediately become electrics by friction, or by the communication of the positive charge from an electric machine, and exhibit the same phenomena as glass, sealing-wax, or any other excited electric. The reason, then, why some substances are electrics and some non-electrics, is because some substances seem to have a greater power of affinity to retain what is collected upon their surface than others.

The body of a living person, for instance, is one of the best conductors of electricity, or non-electrics, and yet it can be made a most perfect electric by insulation.

Our observations thus far, aided by our experiments, have been the means of ascertaining these three facts :

- 1st. *Bodies electrically excited attract bodies unexcited.*
- 2d. *Two bodies electrically excited, as when one excited body has imparted a portion of its electricity to an unexcited body, mutually repel each other.* And

3d. *Two bodies in their natural state have no perceptible influence upon each other, but are perfectly quiescent.*

It follows, then, as a matter of course, that these three facts lay the foundation for three distinct propositions:

1st. *Opposite electrical states attract.*

2d. *Similar electrical states repel.* And

3d. *When bodies are in their natural state, they are in a perfect equilibrium or a balance, exerting neither an attractive nor a repulsive influence.*

The question here naturally suggests itself, What are those two opposite electrical states spoken of in the first proposition? Are they two distinct electrical fluids, or only one? I here use the term fluids, not because I consider it an appropriate term, for I cannot conceive that the word fluidity, in its general acceptance, conveys a correct idea of the movement of electricity, but I use it simply in accommodation to the inappropriate phraseology of those standard works, from the theories of which I am obliged to dissent. Are the opposite electrical states, I say, then, two distinct fluids, speaking in the language of the books, or only one? Eminent philosophers have been divided upon this point. While Du Fay, Symmer, Coulomb, Turner, Thompson and others believed that there are two, with opposite inherent natures, Dr. Franklin, Epinus, and Cavendish, with some modification of each other's views, maintained as positively that there is but one.

I will first state briefly the peculiar views of these two classes of celebrated opponents, examine very minutely their arguments, show how far I agree with

them, wherein I differ, and the reasons which compel me to differ. My object, in thus minutely investigating those two theories, and in attempting to ascertain the truth in the case, is to lay broadly and permanently, upon the immovable and imperishable basis of fact and argument, the foundation of that system of philosophy, the superstructure of which will be built up in future lectures. An error, or a doubt, or an uncertainty *here* will be of serious detriment throughout the whole series, for my theory must stand or fall by the stability or instability of the foundation which I here lay.

The theorists who maintained the existence of two fluids gave their supposed opposite electricities the names of *vitreous* and *resinous*. They called the one *vitreous* because developed, as they supposed, in glass, the word being derived from a Latin term which denotes glass; and the other *resinous*, because developed, as they supposed, in sealing-wax, gum-lac and the other resins, and those two were supposed by them to possess properties entirely and inherently different from each other, each attractive to its opposite, and repellent to itself. Upon this hypothesis they attempted to explain the reason why an excited body attracts an unexcited body, and why like amounts of like electricities, either vitreous or resinous, mutually repel each other.

But, as I shall be under the necessity, with my views of the subject, to differ entirely from their hypothesis, I will let them first speak in full for themselves, and then endeavor to show wherein that hypothesis clashes with fact. And that there may be no injustice

done to those theorists, I will quote the language of one of their most learned and eminent champions. Dr. Turner, in his "Elements of Chemistry," on pages 72 and 73 thus speaks :

"On comparing the electric properties manifested by glass and sealing-wax when both are rubbed by a woollen or silk cloth, they will be found essentially different; and hence it is inferred that there are two kinds or states of electricity—one termed *vitreous*, because developed on glass, and the other *resinous* electricity, from being first noticed on resinous substances. These two kinds of electricity, one or other of which is possessed by every electrified substance, are also termed *positive* and *negative*, the terms *vitreous* and *positive* being used synonymously, as are *resinous* and *negative*. The mode of distinguishing between positive and negative electricity is founded on the circumstance, that if two electrified substances are both positive or both negative, they are invariably disposed to recede from each other, that is, to exhibit electric repulsion ; but if one be positive, and the other negative, their mutual action is as constantly attractive. The end of a silk thread, after contact with an electrified stick of sealing-wax, is repelled by the wax, because both are in the same electric state ; but if a dry, warm wineglass be rubbed with cloth or silk, and then presented to the thread, attraction will ensue. A silk thread, in a *known* electric state, thus indicates the kind of electricity possessed by other substances : a convenient mode of doing this is to draw a thread of white silk rapidly through a fold of coarse brown

paper previously warmed, by which means its whole length will be rendered positive.

“When two substances are rubbed together so as to electrify one of them, the other, if in a state to retain electricity, will be excited also, one being always negative and the other positive. It is easy to be satisfied of this by very simple experiments. Rub a stick of sealing-wax on warm, coarse brown paper, and the paper will be found to repel a positively excited thread of silk, while the wax will attract it. If a warm wine-glass be rubbed on the brown paper, the glass will be positive, as shown by its repelling the positive thread, while the same thread will be attracted by the negative paper. Friction of sealing-wax on a silk ribbon renders the ribbon positive, but with glass the ribbon is negative. If two silk ribbons, one white and the other black, be made quite warm, placed in contact, and then be drawn quickly through the closed fingers, they will be found, on separation, to be highly attractive to each other, the white being positive, and the black negative. The back of a cat is positive to all substances with which it has been tried, and smooth glass is positive to all except the back of a cat. Sealing-wax is negative to all the substances just enumerated, but becomes positive by friction with most of the metals. The reader will perceive from these facts that the same substance may acquire both kinds of electricity, becoming positive by friction with one body, and negative with another. . . . This theory, the fundamental facts of which were supplied partly by Du Fay, and partly by Symmer, is founded on the assumed existence of two electric fluids, which Du

Fay distinguished by the terms *vitreous* and *resinous* electricity. In order to account for electric phenomena by this supposition, the two fluids are assumed to possess the following properties: They are both equally subtle and elastic, universally diffused, and, therefore, present in all bodies, possessed of the most perfect fluidity, each highly repulsive to its own particles, and as highly attractive to those of the opposite kind; these attractive and repulsive forces being exactly equal at the same distance, and both varying inversely as the squares of the distance vary. Electric quiescence is ascribed to these fluids being combined and neutralized with each other; and electric excitation is the consequence of either fluid being in excess. Their combination is destroyed by several causes, of which friction is one. The application of these principles is as follows: Two unexcited contiguous bodies, A and B, are electrically indifferent to each other: for, though each electricity in A repels the electricity of the same name in B, attraction to the same extent is exerted between the opposite electricities, and no change results. If A and B are rubbed together, a portion of the combined electricities in both is decomposed, and the separated resinous fluid is transferred to one of them, suppose to A, and the vitreous to B, each being electrified to the same degree, though oppositely. The free particles of resinous electricity in A tend by their repulsion to recede from each other, and would quit A altogether, unless their passage were impeded by a non-conductor: the atmosphere, if dry, cuts off the retreat, and by its pressure confines the resinous fluid to the surface of A.

The same happens to the vitreous fluid on the surface of B. But the opposite electricities fixed on A and B exert a strong mutual attraction, and may succeed either in forcing their way across the intervening stratum of air, or of actually drawing A and B into contact. In either case the free electricities reunite, and the electric equilibrium is restored. On the contrary, if A and B are similarly electrified — that is, possess the same kind of free electricity — the effort of the electric fluid to escape in opposite directions causes the substances themselves to fly asunder, if the repulsive force exceeds their weight, and thus produces electric repulsion.

“This theory, as commonly stated, takes little or no cognizance of any attraction between the electric fluids and other material substances. But it would be against all analogy to suppose no such influence to exist; and indeed the supposition of an attractive force acting at insensible distances seems necessary to account for the impediment caused by non-conductors to the free movement of the electric fluids.”

Dr. Franklin, the celebrated electrician of our own country, took strong and decided ground against this doctrine. For it he substituted the more simple theory of one fluid, and attempted to account for all the various phenomena of attraction and repulsion by the different states, or degrees, or volumes of electricity, which he called *plus* or *positive* and *minus* or *negative*. When a body had more than its natural share, it was considered to be in a plus or positive state, and when it had less than its natural share, it was considered minus or negative. Bodies, upon

this principle, are positive and negative, relatively, or positive and negative *absolutely*. They are positive and negative *relatively* when they are both plus, but when one has a greater amount than the other. They are positive and negative *absolutely* when one has *more* than its natural share, and the other less. But in each of those cases there is attraction, though much more feeble in the former than in the latter case. Franklin, however, found, after mature reflection upon the subject, that his theory was attended with one inexplicable difficulty. His penetrating mind could not solve it satisfactorily to himself. This difficulty was the repulsion of *two negatives*, which he confessed could not be explained upon the plus and minus theory, for in this case both would be minus, and there would, of course, be an absence of what he considered to be the attractive and repulsive principle.

Epinus, however, a celebrated electrician of St. Petersburg, in Russia, undertook to extricate the theory of Franklin from this dilemma. He maintained, with Franklin, that there is but one fluid, and accounted for all the phenomena of attraction and repulsion, including the repulsion of two negatives, upon the hypothesis that there must be a reciprocal affinity or attraction between ponderable and imponderable matter, and that the particles of each must be mutually repellent to those of their own kind, and mutually attractive to their opposites, and that this attraction and repulsion exerts itself in the ratio of inverse proportions according to the squares of the distance. This, it will be seen, lays the basis for three distinct propositions :

1st. The particles or ultimate atoms of ponderable matter naturally repel each other.

2d. The particles or component parts of imponderable matter or electricity mutually repel each other.

3d. The particles or component parts of both ponderable and imponderable matter mutually attract their opposites, and that, too, with a force which not only varies according to the squares of the distance, but also according to the magnitude and density of the one, and the volume or degree of the other.

Now, from this explanation of the difficulty which Franklin encountered, I dissent altogether. It destroys virtually that "*vis-inertia*" or inaction, which is an essential property of ponderable matter, and gives to it attributes which it never possessed. That difficulty can be explained in a manner more strictly in accordance with fact, for if the theory of one electric agent, as maintained by Franklin, is correct, his doctrine of plus and minus is also correct: but there are certain invariable *results*, which depend upon the plus and minus of bodies, which will fully explain the difficulty which he encountered. We must look, not to the simple volume, or degree, or amount of accumulation itself—not to the simple plus and minus, but to the organic laws of the ultimate component particles of electricity, for the solution of the enigma which so puzzled Franklin, which laws, however, invariably exhibit their operations through the medium of a plus and minus, as Franklin supposed; for all the electrical phenomena depend, after all, upon a plus and minus in bodies.

Owing to the extent of the present lecture, I am

obliged to defer to the next the full examination of the two opposing theories, which have been stated, and shall show wherein I am under the necessity of differing from both, by the existence of a formidable array of facts, and the arguments which can be legitimately drawn from them, which facts and arguments, in my view, preclude the *possibility* of their being correct. The theory of two fluids in particular seems to me so wide from the truth, and so contrary to known and tested laws, that I am somewhat surprised that men of such acknowledged talent and intellectual acumen, as they confessedly are who advocate them, should have given them credence or currency. It must, we believe, in some cases, have been from the fact that they admitted, without examination, upon the mere authority of great names, what they should have thoroughly examined for themselves, unbiased by preconceived opinions, and promptly rejected, if they found the same unsubstantiated by fact. It is unsafe either to regard great names as infallible, or to indulge in fanciful philosophical speculations which have no solid and imperishable basis in the stern and sober reality of things. Whether that stern and sober reality has an existence or not, in any given case, can be ascertained, in most instances, by experiment. In combating those errors in theory, we shall draw all our conclusions from the facts which experiment furnishes.

LECTURE III.

COMMON ELECTRICITY.—CONTINUED.

AS announced in the former lecture, the present will partake largely of a controversial character. Yet we differ with those authors, from whose opinions we shall dissent, *only* because the facts which have been ascertained by ourselves and by others, in the careful observations of the laboratory; compel us to differ. And while we thus differ, we entertain the highest respect for the talents and researches of those eminent scholars. They have thrown great light upon many abstruse and difficult subjects, and we are free and happy to acknowledge the benefit and assistance which we have received from their works.

It is not at all wonderful that there should be diverse and clashing opinions upon the subject of electricity and its various phenomena and influences, since it is an agent so extremely subtle, and since it must be acknowledged that it is not easy to detect, in many instances, the *modus operandi* of its doings, or the primary cause of some of the effects it exhibits. Our arguments and conclusions will, therefore, be liable to misapprehension and misinterpretation, unless great pains be taken to render them as clear and lucid as it is possible for language to make them, and even then we do not expect to escape entirely the common

fate of authors, owing to the imperfection of the fallible medium through which ideas are conveyed from one mind to another. That we may, therefore, avoid, as much as possible, misapprehension, and that the positions to be examined, as well as controverted, may be vividly before the mind of the reader, we will restate them briefly before proceeding in the discussion.

We shall do it, also, for another important reason. The opinions advanced in the following pages will be substantiated, or proved baseless and erroneous, as we establish or *fail* to establish our positions. Much, therefore, it will be seen, depends upon a thorough examination of the opposing and clashing theories of one and two electric agents, and upon the full and satisfactory establishment of the one, and refutation of the other, and, for this reason, we here define the precise positions of the combatants, even at the risk and expense of being thought somewhat diffuse and tautological.

Du Fay, Symmer, Coulomb, Turner, and Thompson promulgated and defended the theory that there are two kinds of electricity, or two distinct electrical agents—that one, if I can understand them aright, resides *inherently* in one substance, and the other *inherently* in another—that each of those two agents is mutually repellent to itself, and mutually attractive to its opposite—and that all the phenomena of attraction and repulsion among bodies are produced by the action or agency of these two electricities.

That it may not be affirmed, by the advocates of this theory, that I have misstated their opinions upon

this point, when their glaring erroneousness and absurdity shall have been made to appear, or stand out prominently to view, even by *their own showing* and their own *self-contradictions*, I will give their own language. Thompson thus speaks of this subject on pages 359 and 360 of his large work on "Heat and Electricity:"

"If we suspend two small pith-balls, by means of a very slender wire, from a stick of sealing-wax, and rub the wax with dry woollen cloth, the two balls will repel each other. If we suspend another pith-ball by a slender wire from a stick of sealing-wax, and rub it also with a dry woollen cloth, this pith-ball, if brought close to the two former, will also be repelled by them. If we suspend the pith-balls by slender wires from dry glass tubes, and rub the tubes with dry woollen cloth, the result will be the same — all the pith-balls will repel each other.

"But if we suspend a small pith-ball by a small wire from a glass tube, and another, in a similar manner, from a stick of sealing-wax, and make the two balls approach, after having rubbed the glass tube and the stick of sealing-wax, the pith-balls, instead of repelling, will *attract* each other."

Now these facts, which Thompson records as having been proven by experiment, we pretend not to deny. They are doubtless true. But we deny, altogether, the conclusions which he draws from these, as his data or premises. He thus reasons:

"Hence it is obvious that the electricity excited in glass" [now mark this] "is *different* from that excited in sealing-wax, since bodies having the *electricity* of

glass attract those having the electricity of sealing-wax, while bodies having each, either the electricity of glass or sealing-wax, repel each other."

Now it has been affirmed, by some of the advocates of the theory of two agents, that Thompson did not say in this passage, or *intend* to say, that glass produces *only one kind*, and sealing-wax *only* the other. But if he does not, by the quotation already made, advance such an opinion, I must confess myself utterly incapable of understanding his language. My intellectual acumen happens not to be sharp enough, if that be the case, to perceive his meaning. Let us examine and dissect the passage a little, for our object is to get at the facts in the case, and elicit truth, and sift it from error. Thompson expressly affirms, without any qualification, that the electricity of glass is *different* from that of sealing-wax. He does not intimate that he considers it to contain any other than that which he says is different. The assumption that he does, for the sake of getting him out of a dilemma, is supplying, by an active imagination, what he has not seen fit even to *hint* at in any of his labored works. Before showing what that dilemma is, from which his apologists would extricate his theory — before placing in striking contrast his palpable *self-contradictions*, and making him refute himself, scholar as he certainly is — I will quote from Turner, another of the most able defenders of the theory we are opposing, to show that Thompson stands not alone in the advocacy of such sentiments.

He says, on page 72 of his Chemistry, as quoted in a former lecture, "On comparing the electric properties

manifested by glass and sealing-wax, when both are rubbed by a woollen or silk cloth, they will be found *essentially* different, and hence it is inferred that there are two kinds or states of electricity, one termed *vitreous* — and why? Mark the answer of Turner — “*Because* developed in glass; and the other *resinous*” — and why? — “*Because* first noticed in resinous substances.” Now, is there the slightest intimation, in this statement of the theory, that glass ever develops but one kind, or resinous substances either? Does he not rather expressly affirm that they are *essentially* different, and if one thing be *essentially* different from another, what logician will insinuate that they are both alike?

Now then for the self-contradictions of the staunchest and most learned advocate of this palpable error in theory. Let Mr. Thompson be arrayed against Mr. Thompson, and let him be refuted by his own statement of facts. There can be no *fairer* system of polemic warfare.

On page 361 of Thompson, he has the following language: “If we rub dry woollen cloth against smooth glass, it acquires negative or resinous electricity, while the glass becomes *positively* electrified. But if we rub woollen cloth against rough glass, it acquires positive electricity, while the glass is charged with negative or resinous electricity.”

Now in this quotation Thompson certainly contradicts his assertions in other parts of his work, if I am able to decipher the meaning of an author. He affirms, in the quotation already dissected and analyzed, that “the electricity of glass is *different* from that of sealing-

wax, and in the facts last quoted he proves that, with the same materials and with the same rubber, both the electricities are developed in glass, and that at least one of its electricities, if it have two, is the same as in sealing-wax, instead of being "*essentially different*," as elsewhere asserted.

This palpable *self-contradiction* arises from the fact that he has undertaken to defend the fanciful speculations of an active imagination, which, as a general thing, passed in his day too much for current truth.

But some one may say that, although a palpable contradiction has been detected, yet that should not impair confidence in the doctrine of two agents. Such a one may affirm that, by rubbing glass, one kind of electricity may be drawn from it, and that by rubbing, with the same rubber, glass of another kind of surface, another kind of electricity may be developed. Although the bare proposition, to my mind, seems most superlatively illogical and ridiculous, yet I will examine it, because it seems to be seriously and honestly believed by its advocates. If it be maintained that there are two electric agents or *fluids*, as they are called, and that they have an attraction for each other, and a repulsion for themselves, they must, according to the facts which Mr. Thompson himself has recorded, both reside in glass. Now, if that be the case, and if they both, as asserted, have a mutual attraction for each other, why should friction call the positive current out of smooth glass and leave the negative, or why should it call the negative current out of rough glass and leave the positive? It may be said by some one, perhaps, that it *does* call both

out, but that the one current runs to the surface of the woollen rubber, while the other accumulates upon the surface of the glass. But why should they do this? If there be two currents of the kind we are examining—if they have a *mutual attraction* for each other, and if friction calls forth both of them at the same time, why should they not, by the force of that attraction, both accumulate upon the same surface? And to show still further the mere fanciful nature of this theory, when brought to the test of fact and of reason, why should a dry woollen rubber accumulate upon itself negative electricity when rubbed against *smooth* glass, and positive electricity when rubbed against *rough* glass? and why should the smooth glass acquire positive and the rough negative at the same time? Not one of these questions can be answered satisfactorily upon the supposition of two fluids. We have to resort to the theory of one fluid to account for these things rationally, though not to the theory of one fluid exactly as taught in the books. Positive and negative do not depend upon the influence of two electricities inherently different, but upon the different degrees of the accumulation of a single current. If a substance, by any cause, acquire *more* than a certain amount, so as to make it plus, with regard to what may be called its natural share, it is positive; but if it have less than a certain amount, so as to make it *minus*, it is negative, and so positive and negative relate to degree or quantity, and to degree or quantity *alone*. Upon this hypothesis, the reason why, in the facts quoted from Thompson, the woollen became positive in one case, and the glass

negative, and why, in the other case, the woollen became negative and the glass positive, was simply because the roughest of two substances, when rubbed together, if both be non-conductors, will impart its electricity to the other, and make that plus or positive, while it becomes minus or negative, and just to the extent that the one is positive, to the same extent is the other negative; so that the one invariably accumulates precisely what the other loses. *This law is universal.* If one substance loses its electricity, just in that proportion *precisely* does the other accumulate it. Not an iota is created by friction. Its quiet is only disturbed; and if it accumulates, it is evident that the substance from which it is accumulated is so far minus.

This accounts rationally, and in accordance with that simplicity and economy which appear throughout nature, for all the phenomena of positive and negative electricity. It is simply accumulation and proportional abstraction. But the reason why two positives repel a positive and negative, and a negative and positive attract, and why two negatives repel, is much more abstruse. It has, for a long time, puzzled philosophers. Franklin, clear-headed as he was, found himself in a dilemma, and confessed it, when endeavoring to solve the mystery of the repulsion of two negatives. Nor is the attempt of Epinus to extricate him from the difficulty entirely satisfactory, although I far prefer it to the irrational and palpable contradictions which cluster thickly around the theory of two electric agents. The opinions of Franklin, reconciled by Epinus, are based upon those three propositions which I stated in a former lecture :

- 1st. Ponderable matter repels its own particles.
- 2d. Imponderable matter repels its own particles.
- 3d. They have a mutual attraction for each other.

But this again might seem to convey the idea that ponderable matter, by its attraction, exhibits inherent activity, which is contrary to fact, for ponderable matter of itself I hold to be perfectly inert. We must examine further, then, to find a philosophical solution for the enigma. Such a solution I think I have found. It is nowhere even hinted at in the books. But because it is not, let no one suppose that I am about to advance a mere fanciful hypothesis, based on no solid foundation of fact. My solution of the difficulty will be derived from a law of electricity, which, although it seems to have escaped the attention of chemists, can nevertheless be demonstrated to exist as easily and as perfectly as any problem in Euclid can be demonstrated. It is this: every ultimate particle of electricity has opposite polarities; that is, each end of each individual particle has a different property — *like* ends or polarities repel, and *unlike* ends or polarities attract. This I intend to prove conclusively by the aid of that immutable truth, that *the laws of a whole are the laws of its parts*, and by the operation of the rule so proven I intend to show that all the phenomena of attraction and repulsion among both atoms and planets can be rationally accounted for. Let us apply the immutable and infallible rule, that the laws of the whole are the laws of its parts, and *see* whether it will sustain the opinion we have hazarded, and for which we derive no support from the books.

Electricity and galvanism are, at the present day,

generally conceded to be the same agent. There is no dispute about that. Now, if you pass a current of galvanism around soft iron, bent into the form of a horse-shoe, and wound, spirally, with insulated copper wire, you make the iron magnetic, and the two ends have different polarities. By different polarities I mean that what one end will attract, the other will repel, or the one is negative, and the other is positive. But by changing the poles of the battery, and passing the current of electricity in a different direction around the spiral wire, you change the polarity of the iron, and make the end that was positive, negative, and the end that was negative, positive, which can be shown by experiments in electro-magnetism. So, then, positive and negative, in this case, depend upon the direction in which the current runs, for the current runs *inward* at one end, and *outward* at the other. The end where the current is *inward* is *always negative*, and that where it is *outward* is *always positive*. And why is this invariably so? There must be a reason for this phenomena. Its solution is readily found in the admirable rule, that the *laws of the whole are the laws of its parts*. If a current of electricity, running in a certain direction, makes one end of a bar of iron positive, and the other negative, each individual ultimate particle of that current must have an agency in producing such a result, and, therefore, each individual particle must have a positive and negative end, the positive end always leading, and the negative, of course, always following. We infer this from the fact that the laws of the whole are the laws of its parts, or the laws of its parts are the laws of the

whole ; for it would be utterly impossible that the whole of a thing should have a quality the *opposite* of the *parts* of which it is composed.

To make our position still more impregnable by fact and argument, let us examine further. If you pass the galvanic current around steel spirally, in the same way as it is passed around soft iron, you make it permanently magnetic. The end where the current is *inward* is *negative*, but the end where it is *outward* is *positive*. So it will remain for years. Now you may cut up that bar of steel, which is thus made magnetic, into ten thousand *pieces*, and *each piece* will have a positive and negative end, and the positive and negative polarities of the pieces will be arranged in the same direction as in the whole. What, then, is the unavoidable and logical inference? Why, that *each ultimate particle of the electricity* that made it magnetic and kept it magnetic has *opposite polarities*, as well as the whole current; because the polarities of the whole are, most assuredly, made up of the properties of its parts. A mere thimbleful of the atmosphere, for instance, contains its relative proportions of oxygen and nitrogen, as well as the whole mass. A drop of water contains its relative proportions of oxygen and hydrogen, as well as the ocean, and so with everything else. Further confirmation, if confirmation it needs, will be given to this opinion when we come to the subject of polarized light.

Having, by fact and by argument, attempted to prove that each end of the ultimate particles of electricity has opposite polarities, that the positive end is always presented in the outward current, and the

negative end, of course, in the inward current, we will now apply this theory to the explanation of the phenomena of attraction and repulsion. But first, to show that the facts are true which we have stated, we can prove them by an experiment with two magnets.

If, for illustration, two steel magnets, with like powers, be dipped into iron filings until they have accumulated as large an amount as they can retain upon their poles, and the opposite poles of each be then presented within a short distance of each other, the filings will spin out, and fill up the space between them, and exhibit an oily, ropy appearance. But if like poles be presented, the filings will be blown back, as it were, and stand out like hair around the points of the magnet. This shows that there is attraction in the one case, and repulsion in the other.

Now, then, for an explanation of the attractions and repulsions of common electricity by this theory. A body which is charged plus or positive has an emanation or an outward current. Such a body will attract a body charged minus or negative. And why? Because, as we have shown by the magnets, the outward current of the body charged plus presents its positive end. But a body in a minus state has an inward current of electricity, which it attracts from contiguous substances. Of course the negative end of the ultimate particles of this inward current is presented. And what is the consequence? Why, two bodies, the one having an outward, and the other an inward current, present opposite polarities to each other, and are attracted from the operation of the immutable law that opposite polarities attract.

We now come to the solution of that difficulty which perplexed Dr. Franklin so much — the repulsion of two negatives. Before the application of this rule the difficulty vanishes at once. When two bodies are minus, or have *less* than their natural share, the current of electricity is inward into both. Now if, while the two currents are inward, the bodies in a minus state be brought near each other, they are repelled, because both currents being inward, the negative ends of the ultimate particles of each current are presented to each other, and they are repelled upon the principle that like polarities repel each other. Thus are all attraction and repulsion among material bodies, and, of course, all motion, produced by the agency of electricity alone, without the intervention or co-operation of inert matter — so that the difficulty which Dr. Franklin encountered in his theory of plus and minus is obviated without the aid of the unphilosophical assumption of Epinus and Cavendish, that matter has the property of repelling its own particles.

But an objection may possibly arise in the mind of some, respecting the repulsion of two negatives, which I will state in the form of a question, and then answer it. If the current of electricity be *inward* into two bodies, why should not the force of the currents setting in bring two bodies together? Such a question would be asked by an objector, who did not understand fully the relative agency of electricity over inert matter. Motion is never produced in ponderable matter by the mere force of moving currents of electricity. If this was the case, our earth would have

been instantaneously battered to atoms by the light which first struck it from the sun. The force of the currents is not a moving cause at all. So subtle are they, that they make no impression of this sort upon matter. But their attractions and repulsions all depend upon an organic law of the ultimate particles — upon polarity, and upon that alone.

There are several other facts illustrative of this law. The upper end of a lightning-rod, for instance, is negative, while the lower end is positive. And why? Because the current is towards the earth, and is, therefore, inward at the top and outward at the bottom. Unless this were the case, it would not have a tendency to draw electricity from the clouds, but repel it.

The shovel, tongs, poker or any other metallic rod or substance which has stood for some time in an upright position — whether in the chimney-corner or in any other upright position — whether within or without the house — imbibe electric properties, and their two extremities always exhibit opposite polarities. This is demonstrated by the fact, that one end will draw the north point of the needle of the compass, while the other end will drive it.

As opposite polarities always attract, we find by this experiment, that the top of such a metallic rod is negative, because it attracts the positive end of the needle, and the bottom positive, because it repels the north point of the needle, upon the principle that like polarities repel.

The longer a metallic rod remains in an upright position, the stronger does its electric, or magnetic,

properties become, until it has become as completely saturated with the wondrous agent, as it can be. Now the question naturally suggests itself, as to the exciting cause of this invariable electric or magnetic property. Why is the top of a metallic bar or rod, which has stood in an upright position for a long time, always negative, and its bottom always positive? or, in other words, why is the stream of electric influence always *inward* at the top, and *outward* at the bottom? Whence does it come? From the sun, undoubtedly, in the passage of the rays of that electrifying agent to the earth, as we shall show more fully when we come to the subject of light. If any chemist can account for the phenomena more philosophically, we should be pleased to have his solution of the problem.

Having fully and minutely examined the theory of one and two fluids, and described what we consider to be the true and *only* true cause of all attractions and repulsions in nature, we must now, in order to render a treatise upon this subject *complete*, just glance at some of the principal benefits, which have been conferred upon the world by the investigations of electricians, which investigations were some of them made at a great personal risk, as will appear in the sequel.

The Leyden jar is an article of electric apparatus, which was inventd by Cunæus, Muschenbrœck, and Allamand, at a very early period of electrical science. But, as it is in common use, in all experiments illustrative of this subject, and as it is fully described in the text-books, we shall just pass with a mere allusion to it.

After its discovery, and the exhibition of the powerful effects of electrical batteries, philosophers could not avoid perceiving the analogy which evidently exists between electricity and lightning. This led to intense investigations of the subtle phenomenon of the storm-cloud. Our sagacious Dr. Franklin led the way. Having discovered that pointed rods of the various metals have the power of discharging electricity, when presented at some distance from the knob of the Leyden jar, the thought occurred to his mind that atmospherical electricity might, by means of that discovery, be made *sensible*. This thought was communicated to M. D'Abilard, of France, and some other electricians of Europe, with the request that they would test the correctness of his opinions by some experiment, as their facilities for procuring suitable apparatus were superior to his own. Following his suggestion, observations were eagerly made by several, and his opinions were proven to be well founded.

In the meantime, however, and before he had received any account of the experiments made in Europe, it occurred to Franklin that, by means of a common kite, he could have access to the floating reservoirs of thunder. Having, therefore, prepared one with a large silk handkerchief, having two cross-sticks, and with no confidant but his son, for fear of the ridicule which would attend an unsuccessful experiment, he walked out into a secluded field at the approach of the first thunder-storm, and with the help of his son, raised it into the atmosphere. He waited some time with anxious and breathless expectation.

One well-charged cloud had passed, and no effect upon his kite was perceptible. Just, however, as he began to despair of success, he noticed that some of the loose threads around his hempen cord, which had, by this time, become a better conductor than at first, owing to the moisture accumulated upon it, would stand out, and apparently avoid each other. Encouraged by this favorable appearance, he presented, though at the risk of his life, his knuckle to the key, which he had tied to the end of the cord, and received a strong spark, attended with a loud snap. Others more brilliant still and in quick succession followed, and thus was fully proven by Franklin, the identity of electricity, and the lightning of the clouds.

This experiment was unconsciously attended with extreme danger, as was subsequently proven in the fate of the amiable, talented, and lamented Professor Richman, of St. Petersburg. The circumstances of his untimely end are thus detailed by Thompson, in his large work on "Heat and Electricity," on pages 435-6:

"He had provided himself with an instrument, which he called an electrical gnomon, the use of which was to measure the strength of electricity. It consisted of a rod of metal, terminating in a small glass vessel, into which he had (for what reason does not appear) put some brass filings. At the end of this rod a thread was fastened, which hung down by the side of the rod when it was not electrified, but when it was, it avoided the rod, and stood at a distance from it, making an angle at the place where it was

fastened. To measure this angle, he had the arch of a quadrant fastened to the bottom of the iron rod.

“He was observing the effect of the electricity of the clouds, at the approach of a thunder-storm, upon his gnomon, and of course standing with his head inclined towards it, accompanied by M. Solokow (an engraver, whom he frequently took with him to be a joint observer of his electrical experiments, in order to represent them the better in his figures), when this gentleman, who was standing close to his elbow, observed a globe of blue fire, as he called it, as big as his fist, jump from the rod of the gnomon towards the head of the Professor, which, at that instant, was about a foot distant from the rod. This flash killed M. Richman ; but M. Solokow could give no account of the particular manner in which he was immediately affected by it. For at the same time that the Professor was struck, there arose a sort of steam, or vapor, which entirely benumbed him, and made him sink down upon the ground ; so that he could not remember even to have heard the clap of thunder, which was very loud.

“The globe of fire was attended with a report as loud as that of a pistol. A wire which brought the electricity to the metal rod was broken to pieces, and its fragments thrown upon M. Solokow's clothes. Half of the glass vessel in which the rod of the gnomon stood was broken off, and the filings of metal that were in it were thrown about the room. The door-case of the room was split through, the door torn off, and thrown into the room. The shoe of the Professor's left foot was burst open, and there was a

blue mark on his foot at that place — from which it was concluded that the electricity had entered by the head, where there were evident marks of injury, and made its way out again by the left foot.”

I cannot resist the inclination to make another quotation here from the same work, respecting the improvement made about this time, and which rendered experiments with the kite much more safe and satisfactory than before :

“ M. de Romas made the experiment with the kite in a more perfect manner than the first attempt of Dr. Franklin. He twisted a fine iron wire into the cord of the kite. To prevent the observer from being exposed to danger, the lower extremity of the string terminated in a silk cord, eight or ten feet in length, by means of which the kite with its string was insulated. Instead of drawing sparks with the finger, which makes the observer himself receive the charge, he received them by means of a metallic conductor, connected with the ground by a chain, which he held in his hand by means of an insulating glass handle, so that it resembled our common discharger. Romas describes the sparks given out from the string to this discharger during a thunder-storm, in a letter to the Abbé Nollet, in very glowing language. ‘Conceive,’ says he, ‘plates of flame, nine or ten feet long, and an inch thick, which make as much noise as a pistol. In less than an hour I had certainly thirty plates of this size, without reckoning a thousand others of seven feet, and below that. But what gave me the greatest satisfaction in this new spectacle was, that the greatest of these plates were spontaneous, and

that, notwithstanding the abundance of the fire which they contained, they fell always on the nearest conductor. This constancy gave me so much security that I was not afraid to draw sparks by means of my conductor, even when the thunder-storm was at its height, although the glass handle of that instrument was only two feet in length. I conducted where I pleased, without feeling in my hand the smallest commotion, sparks of fire six or seven feet long, with the same facility as those whose length did not exceed seven or eight inches.' "

From these successful experiments with the kite, the *practical* benefit of lightning-rods, for the protection of edifices exposed to the destruction of the scathing element, was suggested to the active mind of Franklin, who seemed to be always studying to turn science to a profitable account. These were made by elevating above the highest dome, or spire, or the chimney of a dwelling, a rod with one or more sharp points, to abstract the fluid from the surrounding atmosphere, in most cases *silently*. Down the sides of the edifice these were conducted, and passed into the ground to a considerable depth, being fastened to the walls of the building by iron staples driven into them, with some non-conducting substance between them and the rod, to prevent the passage of a bolt into the wall where the staples entered when the rod happened to be struck by a perceptible flash.

Great improvements have been made since the invention of Franklin, both in the construction of lightning-rods and in the method of putting them up. By such improvements, they have become much

better protectors. They are now made, in some parts of our country, out of square nail-rods, with bearded corners; each joint is made with a ring at one end, and a shank at the other, turned outward about two inches, at right angles with the rod, and pointed, which, when put up, is turned outward from the building and inserted in the ring. Thus each joint, six or eight feet long, has a ring at one end, and a shank at the other, which, when connected together, constitute the upright rod. In addition, a square nail-rod is sometimes extended the full length of the ridge-pole, with perpendicular spikes, having sharp points, about six inches long, attached to it at an interval of every two or three feet, with branches attached to the same, extending above one or more of the chimneys, if the building be a house, or above the spire, if it be a church, and these, so constructed, are connected with two upright rods, erected in the manner before described, at each end of the house or edifice, and passing into the ground. Such rods are an ample protection against any thunder-bolt, whether its passage be perpendicular or horizontal.

It might seem appropriate, before closing this lecture upon Common Electricity, that I should describe the various causes of electrical excitement, show the chemical effects of this powerful and all-pervading agent, and give a solution for the phenomena of winds and storms. But the two former will be reserved for the lectures upon Galvanism, and the latter for those upon Caloric.

I shall, therefore, close with the request that the reader would keep distinctly in view the laws by

which common electricity is governed; for, by arguments and illustrations, based upon those simple and uniform laws, I expect to establish, beyond controversy or reasonable cavil, the positions which I shall take in discussing the more abstruse and difficult topics of some of the following lectures. Yes, I shall depend upon those laws to prove that electricity, and electricity alone, is the prime natural cause of all chemical changes in creation, and all motion among either atoms, or spheres, or constellations of spheres. I thus call the particular attention of the reader to those laws of electricity, because it will doubtless be the case that many will hesitate to give the theory credence, and persist in that hesitation, until convinced by demonstrations which are founded upon the self-evident proposition that "like causes produce like effects."

LECTURE IV.

GALVANISM.

BY minute and careful investigation, and by a variety of practical experiments with apparatus, we have, thus far, ascertained the immutable laws by which the electrical agent is governed. By this investigation we have ascertained that it can be readily excited, and brought from its mysterious repose into action by friction,

“Quick as spark from smitten steel,
From nitrous grain the blaze.”

Well might its singular development astonish those who first beheld it, for a kind of enchantment seems to linger around the subject. By its instantaneous production, upon the proper application of an exciting cause, we are forcibly reminded of the fabulous legends of magic, though we know it to be reality, and not fable. The enchanted ring of Mustapha, the African magician, or the wonderful lamp of Aladdin, when rubbed, brought into the presence of the holder one of the monstrous genii of the fables, irresistibly strong, but yet perfectly docile, and submissive to the will of the person who thus called him. In the same manner, when friction is applied to the cylinder of glass, forth leaps instantaneously the subtle and irresistible agent into

action and visibility, strong but yet docile as the fabled genii, a slave to the will even of an intelligent child, standing ready submissively to obey his dictation, and to do his pleasure, if bidden in accordance with its organic laws.

We have ascertained, also, that under certain circumstances it invariably exhibits an attractive, and under other circumstances invariably a repulsive power, and that this attraction and repulsion are the cause of all the motions among the particles and light bodies of inert matter — that neither the theory of two fluids, as taught by Turner, Thompson and others, nor that of one fluid as taught by Franklin, with the superadded hypothesis of Epinus and Cavendish, accounts rationally and philosophically for the cause of attraction and repulsion — that that cause is to be found in the constitutional organic laws of the ultimate particles of electricity — that each ultimate particle has opposite polarities, from the fact that a current has opposite polarities, and from the self-evident axiom that the laws of the whole are the laws of its parts — that the outward current or emanation is always positive, because the positive end of the ultimate particles of that current is always presented — that the inward current is, upon the same principle, always negative, because the negative end of its ultimate particles is always presented — that two outward currents always repel each other, because the positive pole of the ultimate particles of one current is presented to the positive pole of the ultimate particles of the other, and that two inward currents repel for the same reason, because like polarities always repel,

whether both be positive or both negative — that an outward current and an inward current, when presented to each other, always attract, from the fact that the positive and negative ends of the ultimate particles of those two currents are then presented to each other, and unlike polarities, or positive and negative polarities, always attract. Before this theory, which is capable of absolute demonstration, if there be any certainty in reasoning from the data of self-evident propositions, all difficulties vanish, and every phenomenon of attraction and repulsion can be accounted for philosophically.

It was assumed, at the commencement of this course, that all the imponderables are one and the same agent. This we expect to prove to a demonstration, if we can prove that they are all governed by the very same constitutional or organic laws, and that their effects resulting from the operation of those laws are the same, which we shall certainly do, if there be any truth in that fundamental principle of logic, that like causes produce like effects. Having, then, ascertained the laws and agencies — or the causes and effects of the phenomena produced by this indivisible imponderable principle, under one of its appellations, or in one department of its wondrous operations — we will proceed to the examination of the department next in order, which is denominated Galvanism. Its history would be the first appropriate object of attention and remark.

Galvanism is so called from Galvani, professor of surgical anatomy at Bologna, who was its reputed discoverer, and a scholar of considerable eminence.

Like several other important branches of science, it owes its origin to an accident, which occurred in the year 1791. These were the circumstances of that accident: Mrs. Galvani, at a certain time during the absence of her husband, observed the effect which electricity exerts upon the muscles of dead animals, through the medium of the nerves, from the accidental contact of the conductor of an electric machine with the crural muscle and lumbar nerve of a frog's leg, which had been dressed for food, and was lying upon a table near the machine in the professor's laboratory. This contact immediately produced violent convulsions in the frog. These, Madam Galvani happened to observe, and related them to her husband upon his return. As he was at that time investigating the subject of animal electricity, he seized upon the idea with avidity, and repeated the experiment in a variety of ways with success. And thus — although Galvani is the reputed author and originator of this science — it is to an intelligent and observing lady that the world is doubtless indebted for the discovery of the powers of galvanism.

In connection with this subject, it is worthy of remark that, in the history of the rise and progress of some of the most important sciences, some very trivial circumstance or mere accident has been the prime cause of surprising results and developments. It is somewhere recorded that Sir Isaac Newton was first led to those sublime investigations which overturned the old Ptolemaic system of philosophy, by a circumstance so simple as the fall of an apple, which suggested the subject of gravitation. The furious

and forceful ebullition of a boiling tea-kettle gave rise to a train of thought which resulted in the invention of the steam-engine, and in the propulsion of steam-boats and locomotives, and the same may be said of many other useful inventions. Not only was the science of galvanism discovered by chance, but accident also led to the present arrangement of galvanic batteries.

Upon metallic hooks, which were attached to the iron palisades of Galvani's garden, frogs happened to be hung up by the spine, after they had been dressed, as in the former case, for food (as frog-soup in those days and in those countries was regarded as a very dainty dish, although our epicureans might wonder at their singular tastes). Whenever, by the blowing of the wind, or by any other cause, the frogs were made to swing, so as to touch occasionally the palisades, they were thrown into convulsions. The professor, who observed it, was at first quite puzzled to account for the phenomenon. He imputed it, however, to animal electricity. Professor Volta, of Pavia, objected to this conclusion, and affirmed that it must be the effect of the electricity produced by the contact of two metals, and that the muscles and nerves of the animal were only the medium through which it was conducted, and that the convulsions were produced by the effect of that electricity upon those muscles and nerves. This conflict of opinion with opinion, and intellect with intellect, and the truths and facts which were elicited by the controversy, resulted, at length, in establishing the theory of Volta, that by forming a certain connection between different metals, electricity is produced.

The simplest galvanic arrangement is that in which a piece of zinc is placed beneath the tongue, and a piece of copper above it. Then, whenever the edges of the two metals, thus situated, are brought in contact, there will, whether the eyes be opened or closed, be perceived a slight flash of galvanic light. This flash will be produced as often as the metals are separated and brought in contact again.

By putting a strip of zinc and one of copper into a tumbler of acidulated water, and bringing the two in contact at the top, galvanic effects are produced; or, if they be set upright in the glass, and separate from each other, and in that position be connected by means of two wires soldered to the two plates, which wires are called poles, the same galvanic effects are produced.

The effects which are produced by an arrangement so simple are, however, imperceptible by any of the ordinary processes by which we ascertain the existence of a galvanic current. There will be perceived no sensible flash, if the circuit be broken and closed alternately, through mercury. No shock will be felt by the experimenter, as he forms a part of the circuit, nor will any effect be produced upon the muscles and nerves of animals.

There is, however, an article of apparatus, called a galvanometer, or galvanic multiplier, which was invented by Schweiger, for the purpose of detecting and ascertaining very minute currents of galvanism, and their strength or intensity. This instrument is composed, in the language of Turner, of a copper wire "bent into a rectangular form, consisting of several coils, and in the centre of the rectangle is placed a

delicately suspended needle. Each coil adds its influence to that of the others; and as the current, in its progress along the wire, passes repeatedly above and below the needle in opposite directions, their joint action is the same. In order to prevent the electricity from passing laterally from one coil to another in contact with it, the wire should be covered with silk. The ends of the wire are left free for the purpose of communication with the opposite ends of a voltaic circle. When a single needle is employed in the experiment, its movements are influenced partly by the earth's magnetism, and partly by the electric current. The indications are much more delicate when the needle is rendered *astatic*—that is, when its directive property is destroyed by the proximity of another needle of equal magnetic intensity, fixed parallel to it, and in a reversed position, each needle having its north pole adjacent to the south pole of the other; in this state the needles, neutralizing each other, are unaffected by the magnetism of the earth, while they are still subject to the influence of galvanism. For researches of delicacy, the needles should be suspended by a slender long thread of glass, and the deflecting force measured, not by the length of the arc traversed by the needle, but by the torsion required to keep the needle at a constant distance from the wire, as in the torsion electrometer of Coulomb."

The mutual influence of a magnetic pole and a conducting-wire changes with the distance between them. Experiment shows that the action of a magnetic pole and a continuous conductor, every point of which

exerts a separate energy on the pole, varies inversely as the distance. This result justified the opinion that the force of a magnetic pole on a *single* point of a conductor varies as the square of the distance, the same law which regulates the distribution of heat and light, as well as the effects due to electricity.

It is not absolutely necessary that there should be connected together two plates to produce a galvanic current. A simple voltaic circle may be formed by *one* metal and *two* liquids, so arranged, and possessing such different degrees of decomposing power, that one side of the metal shall be acted upon more intensely by the decomposing agent than the other. In order to test this, let a piece of zinc, for instance, be cemented into a box, so as to leave a cell on each side of the plate. Then, by putting a solution of salt into one cell, and nitric acid into the other, a positive current will run from the cell containing the solution of salt, if the liquid of the two cells be connected by means of a metallic conductor. And galvanic excitement can be produced even with *one* metal and *one* solution, possessing the same decomposing power, provided that the acid in one of the cells be warmer than that in the other; in which case, the warm acid will decompose the zinc more rapidly than the cold, and, of course, a current of positive electricity will set from the side of the plate affected by the warm acid, round to the side affected by the cold.

From the facts developed by the above experiment, it must appear evident to every one that galvanism affords no support to the theory of two fluids. There is evidently but one current, and that appears, as is

abundantly shown by this apparatus, to depend upon a plus and a minus. The side affected by the warm acid decomposes the zinc the most rapidly, and is, therefore, plus with regard to the other side, which decomposes less rapidly. The current, of course, runs from the plus to the minus, in accordance with an immutable and universal law of nature. For what is that current — what, in fact, is galvanism? — but the latent caloric of the metal set free by the combined action of its own powers and those of the acid? And why does the current run from the plus to the minus, if it be not in obedience to a law of caloric, which always seeks to restore and keep up an equilibrium in nature? It certainly must be in obedience to such a law, and we do not believe that any chemist can philosophically and rationally account for it in any other way. It must be something which is set at liberty by the decomposition of the zinc, and the more rapid the decomposition, the greater the amount set free. If that agent, thus set free, be not latent caloric, it would puzzle a philosopher to define what it is.

The current of a battery always runs from the electro-positive metal to the electro-negative, because the electro-positive metal is always rapidly decomposed by the action of the acid, while the electro-negative is scarcely affected at all. The latent caloric, being set free, obeys, therefore, the immutable law of free caloric, and runs from a plus to a minus, and that constitutes galvanism. If this be true, as it doubtless is, it annihilates the last vestige of support for the theory of two fluids, and proves to a demonstration that there is but one. So impressed was Turner with

the fact that galvanism furnishes no support for the doctrine of two fluids, that he seems to have abandoned it, in a measure, in his explanations of the passage of the galvanic current. He says, on page 88 of his *Chemistry*: A current of negative electricity, agreeably to the theory of two electric fluids, ought to traverse the apparatus in a direction precisely reversed; but, for the sake of simplicity, I shall hereafter indicate the course of the positive current only.

A still more efficient arrangement, but yet a very simple one, it being one of the first inventions in the infancy of the science, consists of a series of glasses, or glass tumblers, connected with each other by a metallic arc, with a piece of zinc at one end and a piece of silver or copper at the other. These glasses are filled with some saline or acidulated solution, as salt water, or sulphuric acid, or diluted sulphate of copper, and the circuit is then closed by the experimenter, by putting the fingers of one hand into the glass at one extremity, and those of the other into the glass at the other extremity. In this situation a person will receive a shock every time he replaces his fingers after removing them.

Another very cheap and simple galvanic arrangement can be made by taking a number of pieces of common window-glass, three or four inches square, and after coating them on one side with zinc foil, and, on the other with copper or silver foil, by placing them upon each other, the two opposite metals being always in contact, taking the precaution, however, when coating the glass, not to let the metals cover its entire surface. Each additional plate of glass thus coated

will increase the electric influence of such a pile, but yet some thirty or forty must be so connected in order to give any degree of intensity.

Instead of using glass, which is a non-conductor, if we use discs of paper, which is an imperfect conductor, similar electrical phenomena will be produced, though somewhat more intense, with a given number of coatings of zinc and copper foil. To construct such an apparatus, the most convenient method is to cut the paper into round pieces about the size of a half dollar, suitable for admission within a good-sized glass tube, after having coated them on each side with zinc and copper foil, observing to have the coat of zinc always downward and that of copper always upward, or that of copper always downward and that of zinc always upward, which is immaterial. The tube should be long enough to hold one or two thousand of those discs, and the two ends be closed with some metallic plate in contact with the discs, provided with connecting-wires or poles. The zinc end of such a pile is always positive, and the copper end always negative. And why? Because the current is always outward from the zinc, and inward to the copper, which shows that, relatively, with regard to each other, the zinc is always charged plus, and the copper minus.

Such an apparatus as we have described constituted what has been called the dry columns of Zamboni and De Luc, two of which the latter constructed, and, having placed them near each other, so that the positive pole of the one would correspond with the negative of the other, he suspended between them an

insulated bell, with an insulated ball on each side, which kept up a continual ringing for years, with only now and then a slight intermission. A light insulated needle, properly arranged, and balanced upon a pivot, would oscillate continually between them.

The next improvement in the construction of galvanic apparatus, and one which Thompson remarks "should be ranked among the greatest discoveries, from the enlargement which it has given to our knowledge of electricity, and its effects, and the extension and perfection of chemical science, is the voltaic pile, so called from Volta, professor of natural philosophy at Pavia. If we compare the state of chemistry before the discovery of the voltaic pile, with its present aspect, we cannot but be astonished at the difference; and this difference is, in a great measure, owing to the discoveries made by means of this new instrument of investigation." The improvement spoken of consisted in substituting plates of metal for the foil or leaf, and wet instead of dry columns, which vastly increased its power. This pile consisted of alternate layers of circular plates of zinc and silver, or zinc and copper, with card or paste-board between them, moistened with some saline solution. To the two extremities of this pile, being in opposite states of electricity, conducting-wires were attached, and, when brought into contact, galvanic phenomena were produced. The greater the number of alternate layers of such a pile, the greater the electrical intensity, or, if it be desirable to construct a pile of this kind of considerable power, and it be inconvenient to form it in one pile, two may be used

just as well, by connecting the positive pole of the one with the negative pole of the other.

The prominent leading object which we shall have in view, in our experiments and deductions from them, will be to establish, beyond the possibility of a rational doubt, the identity of the imponderables. One of the illustrations, which will aid in the demonstration of that fact is the similarity between the galvanic and the electric spark. If I alternately break and close the circuit of the pile, as it is called, through the medium of a cup of mercury—that is, if I keep one pole constantly in the mercury, and alternately insert and remove the other, there will be an explosion of a brilliant spark consequent upon every removal, which every one can perceive is precisely similar to the electric spark.

In proof of identity, there is another conclusive illustration. If I place the two poles of the pile in contact with the knob of a Leyden jar, and keep them in contact for some time, the jar will be charged the same as with an electric machine, though its intensity will be somewhat lower. This fact can be shown by discharging it with an electric discharger.

This pile will give out shocks like an electric machine. If a finger of each hand be first moistened with water or some acidulated solution, and be touched to the two poles of the pile, there will be perceived a shock more or less intense, in accordance with the number of plates in the arrangement. Just such a shock will be repeated every time the person trying the experiment shall make and break the connection, by removing and replacing one of his fingers. But

if the finger be continued in contact, without making or breaking the connection, there will be no particular sensation produced, or perceptible, unless there be, somewhere on the hand, a rupture of the skin, in which case there will be experienced a slight burning sensation.

There is another experiment, which will develop a very extraordinary and mysterious fact respecting one of the inherent constituent properties of electricity, which we shall thoroughly investigate in this connection, and see if it does not throw a flood of new light upon the phenomena of disease, the best methods of medical treatment in certain cases, and the hidden organic causes and laws of chemical changes — of decompositions and recompositions. The fact to which I shall allude is this :

If a person shall touch the negative end of the voltaic pile with a moistened finger, and bring a platinum or gold wire from the positive end in contact with the tongue, a strong acid taste will be perceptible in the mouth of the experimenter. But if the wire from the negative end be brought in contact with the tongue while the moistened finger be placed in contact with the positive pole, there will, on the contrary, be produced in the mouth a strong burning or alkaline taste. Now, why is this? The answer to this question might well of itself fill a volume, for it is a key to unlock the rich casket of a thousand mysteries. It cannot, therefore, be expected that I should do more than merely glance at the solution of this wonderful phenomenon, in the space allotted for the completion of this lecture, and if, in my anxiety

to do as much justice to the subject as can be done in a single lecture, I should extend my remarks somewhat beyond the ordinary bounds of one, I hope that my reader will not be offended with this burdensome tax upon his patience.

To proceed, then, why will the *positive* pole, when brought in contact with the tongue, produce an *acid* taste, and the *negative* pole an *alkaline* taste? We shall assume, in the first place, as the basis or data of our reasonings and deductions upon the subject, that it must be something *inherent* in the galvanic current itself, or in some chemical change produced in the system by the course of the passing current, or in both combined. We believe it to be in both combined.

In our investigations of common electricity, it will be recollected that we established, upon the basis of a self-evident proposition or axiom, that one end of its ultimate particles is opposite entirely in its nature to the other end, since one end of a current is attractive and the other repulsive, and, as the laws of a whole are the laws of its parts, then, of course, each atom of that whole has an attractive and a repulsive power, by the opposite polarity of its opposite sides. Now then, if, as is demonstrated in the experiment just referred to, the whole current has a taste, just in accordance with the direction in which it runs across the tongue, each ultimate particle, which aids in constituting that current and its organic laws, has also a taste in accordance with the direction in which *it* runs, as can be proven by the same process of reasoning.

It is demonstrated, then, by experiment and by

deductions built upon self-evident propositions, that each of the two ends of the ultimate particles of electricity have opposite tastes — the one an alkaline and the other an acid taste.

Now how admirably this fact exhibits the uniformity of nature's laws! How lucidly it proves that there is no clashing at all in the principles of her government! What a firm and immovable basis it lays for confidence, that, when we have ascertained, beyond the possibility of doubt, one isolated fact, proving the existence of a certain definite law, other facts, when discovered, will harmonize with the evidence of the first fact, if they relate to the same subject or class of subjects, and will increase the weight of proof as to the existence of such a law, thus chaining the uniform testimony of isolated facts together into an harmonious and irresistibly convincing sum-total of proof, and thus giving a satisfactory and almost mathematical certainty to our knowledge!

What is the corroborating testimony of facts in the case under consideration? It is this: We demonstrated in our last lecture, by a series of deductions based upon experiments, that the two ends of every ultimate particle of electricity have opposite polarities — that when a body is charged plus there is an emanation — that in every emanation or outward current the ultimate particles of the agent that constitutes it present their positive end, as that always leads — that a minus body has an *inhalation* of the electric breeze, as it were, or an inward current from surrounding substances, and is negative, because the rear end of each particle, or that which always follows

the lead of the positive in all the movements of electricity, is, in its organic constitution, negative.

Now then for a forcible illustration of the admirable uniformity of those facts which demonstrate nature's laws. When a current of electricity runs *in* at the tongue, it leaves an *acid* taste, and when *out* of the tongue, an *alkaline* taste. Now the inward current, as we have before frequently remarked, presents its *negative* end, and the outward its *positive* end. In the inward current, the negative end of each particle, as it passes in, gives inherent organic taste, and so with the other. Now, in what electrical states are the alkalies and the acids? Why, exactly in *opposite* states. The acids are negative, and the alkalies are positive. The inward current has a *negative* polarity, and is also *acid*, and the outward has a *positive* polarity and is *alkaline*. The positive and negative, then, in both cases—yea, in the whole three cases, agree perfectly, both as to *taste* and *polarity*—the taste of the negative end of a current being acid, which acid in the form of salts is also negative, and the taste of the positive end of a current being alkaline, which alkaline, in the form of salts, is also positive. The strong chemical affinity which exists between the alkalies and the acids is familiar to all. Tartaric acid and soda, for instance, when brought in contact with each other in solution, are attracted to each other, a powerful effervescence ensues, and a chemical union is formed between the two. Now this attraction must be entirely owing to the attraction of positive and negative electricity, or of opposite polarities, since the one is plus and the other minus, and since a founda-

tion seems to be laid for an alkali and an acid in the organic constitution of the ultimate particles of electricity itself.

In the harmonizing facts which the experiments develop, we doubtless discover the very fundamental cause of all chemical attractions or affinities, and, of course, of all chemical changes, as well as the causes of disease and the most appropriate remedies for such disease.

After having given a further description of the progress of the science of galvanism in the construction, improvement, and use of apparatus, we will then discuss in full the several topics of the chemical decomposition of substances, the various causes and phenomena of disease in the human system, so far as they depend upon the different electrical states of that system, and the appropriate remedies for such disease and the chemical reasons why such remedies in certain cases are available.

The next invention which followed those to which we have alluded was that of the trough or galvanic battery, by Mr. Cruikshanks, of Woolwich, England, which succeeded the voltaic pile, and, with improvements, is now generally used. His trough consisted of baked mahogany, about four inches wide and four deep. Into grooves cut in the sides and bottom of this trough, at small distances from each other, were inserted alternate plates of zinc and copper soldered together at the ends, and cemented into the grooves by sealing-wax, or some other similar material, so as to prevent the water from passing from one cell to another. Into these insulated cells was poured either

a saline or strongly acidulated solution, and the extreme plates were brought into connection by means of conducting-wires, called poles.

This battery was very materially improved by so constructing it that the zinc plates could be lifted out of the cells when not in use, and thus their otherwise rapid corrosion was, in a measure, prevented.

Following this are the improvements made by Dr. Hare, of Philadelphia, and which are thus described by Thompson :

“ Dr. Hare,* professor of chemistry at Philadelphia, has contrived a new modification of the galvanic apparatus. He takes two plates, one of copper and the other of zinc, and placing a disc of leather between the two, he rolls them up in the form of a spiral. The leather disc is now removed, and the two metals are prevented from touching each other by interposing slips of wood. Each of these plates is made to communicate with a plate of a different kind of metal, the zinc with copper, and the copper with zinc, precisely in the way already described when giving an account of the troughs. A number of these double spirals are fixed upon a piece of wood in the same way as has been just explained. These cylinders are now introduced, each into a cylindrical glass vessel. This method of construction is attended with several important advantages. By this contrivance, plates of a very large size may be introduced into a small vessel ; so that the expenditure of liquid is the least possible ; besides, the greatest part of the two sides of each plate is active, being placed opposite to a face of the other metal.

* Dr. Hare died a number of years since.

“Dr. Hare has constructed another apparatus, which he calls a *deflagrator*, and which appears to possess very great power. He takes a plate of zinc three or four inches square, and closes it in a case of copper, distant from it about a line, and touching it nowhere. Any number of these plates, thus enclosed in copper, is attached to a horizontal piece of wood, and fixed immovably, that there may be no risk of the plate of zinc touching the copper case in which it is enclosed. The zinc plate at the first of these is united at the top to the copper case of the next zinc plate; and this is continued through the whole. These copper cases are placed at a very small distance from each other, and between each pair is introduced a piece of card dipped in linseed-oil, varnish, and half dry. They are then compressed so as to adhere so closely to each other that no water can insinuate itself between them. Things being thus disposed, the apparatus is plunged into a trough containing the liquid, and not divided into cells; the varnished card answering all the purposes of the diaphragms in the porcelain troughs. Four such pieces of apparatus, containing each fifty plates of zinc, surrounded by its copper case, when plunged into the proper troughs produce very powerful effects.

“The apparatus employed by Oersted, and of the efficacy of which he speaks in high terms, approaches very nearly to this last one of Hare. Indeed the theoretical construction of both is the same.”

I have not time to describe the various experiments and improvements of Morichini, Professor Oersted, of Copenhagen, Sir Humphrey Davy, and several

others. I would only remark that it has been ascertained that an arrangement of a very large number of small plates constitutes the kind of battery to be used in giving shocks and in chemical decompositions, and that an arrangement of a few plates, exposing a very large surface, constitutes the proper kind for evolving very great heat.

Dr. Ure, of Glasgow, in Scotland, performed, some time since, upon the body of a murderer, who had been hung, several experiments with a battery of the former kind, consisting of two hundred and seventy pairs of four-inch plates.

1st. One pole of this battery was introduced into an incision in the nape of the neck, so as to come in contact with the spinal marrow, while the other was applied to what is called the sciatic nerve. The consequence was that every muscle of the body was agitated with a convulsive quiver, as if violently shuddering from the effect of cold.

2d. By continuing one pole in the nape of the neck, as before, and removing the other to an incision made in the heel, the knee being previously bent, the leg was thrown out with such force and violence as nearly to kick over one of the assistants who attempted to prevent its extension.

3d. One pole was inserted in an incision made to what is called the phrenic nerve, and the other between the ribs, so as to touch the diaphragm at the bottom of the lungs. The consequence was that the chest rose and fell as in heavy natural breathing.

4th. One pole was brought in contact with the supra-orbital nerve in the forehead, and the other with

the heel, when every muscle of the countenance was simultaneously thrown into fearful action. Rage, horror, despair and ghastly smiles united their hideous expression in the murderer's countenance. So horrid was the sight that several spectators were forced to leave the room in which the experiments were made, either from terror or sickness, and one gentleman fainted.

5th. One pole was inserted again in the nape of the neck, and the other brought in contact with the ulnar nerve at the elbow. Immediately the fingers moved nimbly like those of a violin-performer. An assistant tried to close the hand, but found it would open forcibly, in spite of his efforts. When the rod was removed from the elbow to a slight incision in the forefinger, the fist being previously clenched, that finger instantly extended, and, by the convulsive agitation of the arm, the murderer seemed to point to the different spectators, some of whom thought he had come to life.

With the foregoing series of interesting experiments, we shall bring to a conclusion the present lecture, and defer the further consideration of galvanism to the next, requesting the reader, however, before we dismiss the subject, to keep in recollection those experiments in particular, as we think they will throw some light upon the subject when we come to consider the agency of the electric principle in the various departments of organic life, and the abstruse science of Pathology.

LECTURE V.

GALVANISM. — CONTINUED.

BEFORE commencing a discussion upon the subject of the chemical changes produced by the imponderable principle in ponderable matter, whether organic or inorganic, we will give a description of one or two other important pieces of galvanic apparatus now in use.

Dr. Hare's calorimotor, as it is called, is a battery of the other kind, which evolves great heat, and yet produces but a slight electric effect upon the muscular system, and in the chemical decomposition of substances. He constructed it of several eighteen-inch plates, and had it so arranged that all the plates of copper were joined together by a band of metal, and those of zinc in the same way. By this arrangement, all the plates became, in fact, but one pair, having an immense surface exposed to the galvanic action.

Mr. Children, of England, in 1814 constructed one of this kind, consisting of twenty pairs of zinc and copper plates, each six feet long, and two feet six inches broad, joined together with straps of lead. By immersing this battery in a mixture of nitric and sulphuric acids, with from twenty to forty times their weight of water, the following experiments were made: A platinum wire five feet six inches long, and

$\frac{11}{100}$ of an inch in diameter, was made red-hot throughout, so that the ignition was visible in full day-light. Eight feet and six inches of platinum wire, $\frac{44}{100}$ of an inch in diameter, were heated red. A bar of platinum, $\frac{1}{6}$ of an inch square and two inches and a quarter long, was heated red-hot, and melted at the end. A round bar of the same metal, $\frac{276}{1000}$ of an inch in diameter, and two and a quarter inches long, was heated bright red throughout.

Before passing to other topics, it may be appropriate, in connection with the subject of galvanic batteries, to remark upon the different solutions used in experimenting, and their various effects. This we will do in the language of Thompson, page 517 :

“The energy of the galvanic battery depends very much upon the nature of the liquid employed as a conductor between the pairs of plates. The better conductor of electricity it is, the more powerful, *ceteris paribus*, is the energy of the battery. When we employ pure water, the energy is a minimum. Indeed, it seems doubtful whether the pile possesses any activity, when the water used is perfectly pure, and perfectly freed from atmospherical air. Water containing a salt in solution answers much better, because the addition of a salt increases very much the conducting power of water. Common salt, sulphate of soda, alum, nitre, or sal-ammoniac, are often employed. The more easily the salt is decomposed, the better does it answer. Acids on that account answer better than salts. The three acids usually employed are the sulphuric, muriatic, and nitric. Of these the muriatic acid has the least energy; the sulphuric

comes next in order: but the nitric acid is the most efficacious of all.

“The stronger the saline or acid solution is, the more powerful is the action of the battery. The action of nitric acid is the most energetic; but it ceases most speedily. The experiments of Gay Lussac and Thenard have shown that the addition of ten, twenty, thirty, etc., parts of concentrated nitric acid to a given weight of water, increases the intensity of the battery ten, twenty, thirty, etc., times, or that the energy is directly proportional to the strength of the acid employed. The charge usually employed in this country is a mixture of one part of concentrated acid with about twenty or twenty-five parts of water.

“The action of the sulphuric acid lasts longer than that of the nitric, and that of the muriatic is more lasting than that of the sulphuric. The addition of some sulphuric acid to the nitric acid solution (as was the practice of Sir H. Davy) renders the action much longer, because the sulphuric acid prevents the nitric acid from being saturated by the oxide of zinc formed. The energy, of course, continues till the whole nitric acid is decomposed.

“Of the salts, sal-ammoniac is the most powerful. A solution of common salt in vinegar acts well, and is most commonly used by experimenters, as the cheapest ingredient likely to answer the purpose.”

Having given a sufficient account of the galvanic apparatus, it is time to turn our attention to the effects which it produces.

In a former lecture of the course, we assumed, it will be recollected, that there were but *three* essential

principles in creation—viz., *ponderable matter*, *imponderable matter*, and *mind*, and that all the chemical changes within the whole wide range of philosophic investigation were produced by the energizing influence of the imponderable principle over ponderable matter. This, we are aware, is stating a proposition, somewhat new, in strong and decided terms—is taking a position which has not been definitely taken by any standard authors upon the subject, although they have published many things and facts which will be of very essential service in aiding to establish fully what we are attempting to demonstrate; and, as many may, very probably, be disposed to regard the position as wholly untenable, we shall first quote largely from Thompson to show what has been ascertained by experiment, as he seems to have taken much pains to collocate and condense the recorded results of the labors of learned and practical chemists.

Our first examinations will be confined to inorganic substances, and, as we quote the opinions of others, we shall regard them merely *as* opinions, disconnected entirely from the facts recorded, which opinions we shall not regard as resting upon an infallible basis of reasoning, nor shall we endorse their conclusions as resulting necessarily from the facts in the case, except where it shall appear perfectly conclusive that they do.

We shall also premise another thing before proceeding to make those quotations: they may not be arranged exactly in that methodical order and concise form which would strictly comport with a work designed to be so condensed as this.

We will first quote what Thompson says, between

pages 491 and 495, under the head of "Electricity by Contact:."

"A considerable number of experiments on electricity by contact were made by Sir H. Davy. When oxalic, succinic, benzoic, or boracic acid, perfectly dry, either in powder or in crystals, are touched upon an extended surface with a plate of copper, insulated by a glass handle, the *copper* becomes *positive*, and the *acids negative*. When zinc or tin is substituted for copper, the effect is the same. Phosphoric acid, perfectly dry, when applied to copper becomes negative, and the copper positive. When metallic plates are made to touch dry lime, strontian, barytes, or magnesia, these alkaline bodies become *positive*, the metal *negative*. With soda the effect is the same. Potash attracts moisture so rapidly that the experiment cannot be tried with it. When sulphur is applied to polished lead, or to any other metal, it becomes positive.*

"It has been ascertained that electricity, when employed in the way described heretofore, and known by the name of the voltaic battery, is capable of decomposing all compound bodies, and the decomposition takes place according to a particular law. When two platinum wires attached to the two poles of the battery are plunged into a vessel of water, the water is reduced into its elements, and the *oxygen* is always extricated from the wire attached to the *positive* pole, while the *hydrogen* rises from the wire attached to the *negative* pole. When the wires are plunged into a strong solution of muriatic acid, the

* Phil. Trans., 1807, p. 34.

chlorine is accumulated round the positive wire, and the hydrogen round the negative. The law according to which *hydrobromic* and *hydriodic* acids are decomposed is the same. The bromine and iodine are attracted to the positive pole, while the hydrogen is attracted to the negative pole. When chloride of sodium or potassium is decomposed, the chlorine passes to the positive pole, while the sodium and potassium pass to the negative pole. Were a compound of sulphur with oxygen to be decomposed, the oxygen would attach itself to the positive pole. But with sulphuret of zinc or of iron the case would be different; the sulphur would collect round the positive pole, and the metal round the negative pole. When salts are decomposed, the acid is attracted to the positive pole, and the base to the negative.

“Now, as bodies are attracted by those in a different state of excitement from themselves, it also follows that oxygen, chlorine, bromine, iodine, and acids would not be attracted to the positive pole, unless they themselves were in a negative state; nor would hydrogen and bases be attracted to the negative pole unless they were in a positive state. From this it has been concluded that bodies which have an attraction for each other are in opposite states of electricity, and that it is to these opposite states that their attraction for each other, and their union with each other, are owing. The current of electricity destroys their union by bringing them into the same electrical state. In consequence of this view, which is at least exceedingly ingenious and plausible, bodies have been divided into two sets—those which are

negative, and those which are positive. The following table exhibits a list of the negative bodies, beginning with those which possess the negative property in the highest degree, and terminating with those in which it is lowest :

Oxygen,	Molybdenum,
Chlorine,	Chromium
Bromine,	Tungsten,
Iodine,	Boron,
Sulphur,	Carbon,
Phosphorus,	Antimony,
Selenium,	Tellurium,
Arsenic,	Columbium,
Titanium,	Silicon.

“The following table exhibits a list of the positive bodies, beginning with the one in which the property is weakest, and ending with the one in which it is strongest :

Gold,	Uranium,
Platinum,	Iron,
Palladium,	Cadmium,
Osmium,	Zinc,
Iridium,	Manganese,
Rhodium,	Aluminum,
Mercury,	Thorinum,
Silver,	Yttrium,
Copper,	Glucinum,
Nickle,	Magnesium,
Cobalt,	Calcium,
Bismuth,	Strontium,
Tin,	Barium,
Zirconium,	Lithium,
Lead,	Sodium,
Cerium,	Potassium.

“It is not easy to decide where hydrogen should be placed. Compared with oxygen it is strongly positive. But it combines with the potassium, and must with respect to it be negative. The bodies nearest the head of the first list being most powerfully negative, have the greatest chemical affinity for each other. Bodies in the same list have but little affinity for each other; those towards the bottom of the first list have but little affinity with those towards the top of the second list. However, the bodies in the same list are not destitute of affinity for each other. Thus, sulphur combines readily with arsenic. Because these two bodies assume different states with respect to each other. When we decompose sulphuret of arsenic, the sulphur is attracted to the positive pole, and the arsenic to the negative — showing that the former is in a negative state, and the latter in a positive. It is for this reason that almost all the substances constituting the first list are capable of uniting with each other as well as with those of the second. Now, it deserves attention, that when the bodies constituting the first list unite with each other, they constitute *acids* or substances which act the part of acids; when they combine with the substances constituting the second list, they constitute *bases* or substances which act the part of bases. All the acids are combinations of the negative bodies with each other; all the bases are compounds of the negative bodies with the positive. I have left out azote, because it is not easy to say where it ought to stand; but it belongs undoubtedly to the class of negative bodies, and should stand probably before *sulphur*.

“Hydrogen I have purposely omitted. It constitutes *acids* by combining with the greater number of the negative bodies; but we are ignorant at present of any compound which it forms with any of the positive bodies, excepting with potassium, which, according to the experiments of Gay Lussac and Thenard, absorbs hydrogen gas and forms a compound. But this combination has not succeeded in the hands of other experimenters.

“Ever since the discovery of the identity of lightning and electricity, the attention of electricians has been turned to the accumulation of electricity in the atmosphere. And various causes for such an accumulation have been assigned. The opinion of Volta has been most commonly adopted. According to him, whenever a body changes its state, it becomes electric. Now, water is continually ascending into the atmosphere in the state of vapor, or falling from it in the state of rain. By these continual changes of state, which this fluid undergoes, Volta supposed that the accumulation of electricity in the atmosphere was chiefly produced. This opinion was verified by Lavoisier and Laplace. But when Saussure repeated the experiments, he was unable to obtain any satisfactory results. M. Pouillet has recently examined the subject with much care, and has found that no sensible quantity of electricity is evolved when water changes its state, unless at the same time some chemical action more or less vigorous accompanies the change. But whenever two gaseous bodies unite with each other, or a gaseous body with a solid body, one of the uniting bodies always gives out positive

electricity, and the other negative electricity.* These experiments being of great importance, both for understanding the sources of atmospherical electricity, and for determining the kind of electricity possessed by those bodies which have a chemical affinity for each other, it will be worth while to state them somewhat particularly. When charcoal is burnt it sometimes gives out positive, and sometimes negative electricity, and sometimes no electricity at all. This depends upon the way in which the combustion is conducted. To obtain constant results, M. Pouillet proceeded in the following manner: He took a piece of charcoal of such a diameter that it could receive the form of a cylinder whose bases were nearly plain. This piece of charcoal was placed vertically, two inches and a half, or three inches, below a plate of brass which rests upon one of the discs of the condenser. The charcoal communicated with the ground, and was lighted at its superior base, taking care that the fire did not reach the lateral surface. A current of carbonic acid rises and strikes against the plate, and in a few minutes the condenser is charged. The electricity which it receives from the carbonic acid gas is always *positive*. If the plane be allowed to communicate to the sides of the charcoal, or if it be inclined so that the carbonic acid formed must slide up along the base of the charcoal, no sensible effect is obtained.

“To obtain the electricity which the charcoal itself takes by combustion, M. Pouillet placed its inferior end directly upon the disc of the condenser, and then

* Ann. de Chim. et de Phys., xxxv., 401.

lighted its superior base. In a few minutes the condenser was charged with negative electricity. From these experiments, we learn that when charcoal is burnt it becomes charged with negative electricity, while the carbonic acid evolved is charged with positive electricity. Now, the combustion of charcoal is the combination of it with oxygen, so as to constitute carbonic acid. According to Pouillet, during this combination, the oxygen gives out positive electricity, which is found in the carbonic acid gas, while the charcoal gives out negative electricity, which is found in the portion of the charcoal not yet burned. Now, when the carbonic acid gas is again decomposed into its elements, the oxygen takes back positive electricity, and the carbon negative electricity. Is not this the reason why the oxygen gas is attracted towards the positive pole of the voltaic battery, while the carbon is attracted to the negative pole?

“The flame of hydrogen gave contradictory results with respect to its electricity, as has been the case also at first with charcoal. In the course of a few minutes it gave indications both of positive and negative electricity; very intense and very weak indications, and often it was impossible to obtain any indication at all. But these difficulties were at length overcome by M. Pouillet in the following manner:

“The hydrogen gas was made to flow out of a glass tube. The flame was vertical, having a breadth of four or five lines, and a height of about three inches. A coil of platinum wire was employed to conduct the electricity from the flame to the condenser. When this coil was so much larger than the flame as to

enclose it, and to be distant from its external surface about four inches, signs of positive electricity made their appearance. These signs became more and more intense as the distance diminished. But when the coil became so small as to touch the flame, the electrical signs became weak and uncertain. Thus it appears that round the flame of hydrogen there is a sort of atmosphere at least four inches in thickness, which is always charged with positive electricity.

“If a very small coil of platinum wire be placed in the centre of the flame, in such a manner that it is enveloped on all sides, and made to communicate with the condenser, that instrument becomes immediately charged with negative electricity. Thus it appears that the outside of the flame of hydrogen gas is always charged with positive electricity, and the inside with negative electricity. It follows from this that there is a layer of the flame where the electricity is invisible. Accordingly, if we regulate the coil in such a manner that it penetrates nearly one-half into the bright part of the flame, all electrical indications disappear.

“From these experiments, it appears that the electricity evolved during the combustion of hydrogen is quite similar to what appears during the combustion of charcoal. The oxygen, before it enters into combination, is charged with positive, and the hydrogen with negative, electricity. Oxygen, then, must part with positive electricity when it combines with hydrogen, and hydrogen must part with negative electricity when it combines with oxygen.

“If, instead of making the hydrogen gas flow out

of a glass tube, we make it flow out by a tube of metal which does not communicate with the ground, but only with the condenser, this metal tube which touches the hydrogen, but not the flame, always becomes charged with negative electricity. But if it communicate with the ground, it loses the negative electricity which it had lately carried to the condenser, and the product of the combustion preserves an excess of positive electricity.

“If we examine at a height of a few inches above the vertical flame, we find both the electricities in the same quantity and not recomposed. For if we present a soldered plate of zinc and copper, the zinc plate attracts the negative, and the copper plate the positive electricity. When we go to a distance sufficiently great above the vertical flame, the electrical fluids can no longer be recognized, because they have combined and neutralized each other.

“Pouillet examined the flames of alcohol, ether, wax, oils, fat, and many vegetable bodies which presented the same phenomena as that of hydrogen; that is to say, that a zone of air surrounding the flame was electrified plus, while the interior of the flame was electrified minus. All these combustions exhibit examples of oxygen uniting with hydrogen and carbon. The oxygen gives out positive electricity; while the combustible body, whether hydrogen or carbon, or a compound of the two, gives out negative electricity.

“It has been ascertained by the experiments of Priestly, Ingenhouz, Sennebier, Saussure, etc., that plants while vegetating act upon atmospherical air;

sometimes forming a great quantity of carbonic acid, which disengages itself insensibly, and sometimes, on the other hand, give out oxygen gas in a state of greater or less purity. Now, it appears, from the preceding experiments, that when carbonic acid is formed by combustion, it is electrified plus. This led M. Pouillet to suspect that the carbonic acid given out during the processes of vegetation would be in the same predicament. To determine this point, he made the following experiment :

“Twelve glass capsules, about eight inches in diameter, were coated externally for two inches round the lips with a film of lac-varnish. They were arranged in two rows beside each other, either by placing them simply on a table of very dry wood, or by putting them on a table previously varnished by gum-lac. They were filled with vegetable mould, and were made to communicate with each other by metallic wires, which passed from the inside of the one to the outside of the other, going over the edges of the capsules. Thus the insides of the twelve capsules, and the soil which they contained, formed only a single conducting body. One of these capsules was placed in communication with the upper plate of a condenser by means of a brass wire ;* while at the same time the under plate was in communication with the ground. Things being in this situation, and the weather very dry, a quantity of corn was sown in the soil contained in the capsules, and the effects were watched. The laboratory was carefully shut, and neither fire, nor light, nor any electrified bodies were introduced into it.

“During the first two days the grains swelled, and the plumula issued out about the length of a line, but did not yet make its appearance above the surface of the earth. But on the third day the blade appeared above the surface, and began to incline to the window, which was not provided with shutters. Consequently the carbonic acid gas, which disengages itself during the germination of seeds, is charged with positive electricity, and is therefore precisely in the same state as the carbonic acid gas formed by combustion. This experiment was several times repeated with success. But the electricity cannot be recognized unless the weather be exceedingly dry, or unless we dry the apartment artificially by introducing substances which have the property of absorbing moisture.

“These capsules being insulated, and the air being very dry, and the soil so dry that it is an imperfect conductor, it is evident that the electricity would be retained. Accordingly, when the condenser was brought into a natural state after one observation, and if it was then replaced for experiment only during one second, it was found to be charged with electricity.

“It is obvious enough that the gaseous fluids given out by plants during the process of vegetation, being charged with electricity, must contribute to furnish no inconsiderable portion of the electricity with which the atmosphere becomes loaded. No doubt the carbonic acid gas evolved from animals by respiration is also charged with positive electricity; though it would be somewhat difficult to determine the point by actually charging a condenser, in consequence of

the moisture with which the expired air is always loaded." *

Other important agencies of galvanism are described by Thompson, commencing on page 529 of his work on "Heat and Electricity," which we shall quote in full before proceeding to comment upon them, and to make them the data of certain deductions which have a bearing upon the settlement of the question at issue :

"The chemical effects of the voltaic battery have been investigated with much sagacity, and have thrown a flood of light upon the nature of chemical combination. Every substance constituting the liquid conductor interposed between the pairs of plates undergoes decomposition, one of its constituents being attracted to the positive plate, and the other to the negative. Suppose the liquid conductor to be *water*: the *oxygen* is attracted to the positive or zinc plate, which it converts into an oxide, while the other constituent, the *hydrogen*, is attracted to the negative or copper plate. Hydrogen does not combine with copper. It therefore makes its escape from the face of the copper plate in the form of hydrogen gas. When pure water is used, the decomposition is exceedingly slow, because pure water conducts electricity of low intensity very badly. If we add nitric acid to the water, the energy of the battery is very much increased, because the conducting power of the liquid is greatly

* The reader may consult with advantage an elaborate and most ingenious set of experiments by Sir H. Davy, to establish his own views, which are inconsistent with those of Pouillet, in *Phil. Trans.*, 1826, p. 398.

augmented, and because the nitric acid undergoes decomposition much more easily than water. In this case both of the constituents of the liquid conductor undergo decomposition; the water is reduced into its elements as before, and the oxygen, as before, unites to the zinc plate, while the hydrogen is disengaged from the copper plate. The nitric acid is decomposed into oxygen and deutoxide of azote. The oxygen unites to the zinc, while the deutoxide of azote is disengaged in abundance from the copper plate. If the nitric acid solution used possess considerable strength, a good deal of heat is evolved, and the quantity of deutoxide of azote and hydrogen given out is very annoying to the experimenter. The zinc is oxidized and dissolved very fast, and the energy of the battery is soon destroyed; because, in a very short time the whole nitric acid is either decomposed, or combined with the oxide of zinc. The liquid becomes a solution of nitrate of zinc in water, which is, comparatively speaking, a bad conductor of electricity.

“It would appear that, while the energy of the voltaic battery continues, two opposite currents of electricity pass through every stratum of liquid, interposed between every pair of plates. The negative electricity passes towards the copper plate, and the positive electricity towards the zinc plate. To form a conception of the way in which these currents pass, let us consider the conducting liquid in its simplest state, or consisting of water. Water is a compound of oxygen and hydrogen. Let us consider only a single row of the particles of it, lying between the zinc and copper plate. Let Fig. 1 represent oxygen,

and Fig. 2 hydrogen. A particle of water may be represented by the symbol $\frac{1}{2}$, and a row of particles of water may be represented thus :



The current of negative electricity seems to pass along the particles of oxygen, and the current of positive electricity along the particles of hydrogen. From M. Pouillet's experiments, related in the last section, it would follow that, when oxygen and hydrogen combine, the former gives out positive, and the latter negative electricity. We may conclude from this that, when they become charged again with these respective electricities, they will separate from each other. The particle of oxygen next the zinc plate, being thus disengaged from particles of hydrogen with which it was united, will be attracted to the zinc plate, give out its electricity to it, and combine with it. The same thing will happen to the particle of hydrogen nearest the copper plate. The electricity constantly passing along the row of particles will occasion a succession of decompositions of the particles of water. But the hydrogen in each will instantly combine again with the next particle of oxygen in succession. It is not then the hydrogen which passes through the liquid from one plate to the other, but a rapid succession of decompositions; and as the first particle of water has parted with its oxygen, it is obvious that the last particle must part with its hydrogen.

"The same explanation applies to all the decompositions that take place in the liquid interposed

between the respective pairs of zinc and copper plates. But it is usual to interpose between the two poles of the voltaic battery a vessel containing the water or other substance to be decomposed. A platinum wire is made to pass into this liquid from each pole, and the series of decompositions may thus be observed.

“The nature of these decompositions was first investigated by Berzelius and Hisinger, in a paper published by them in Gehlen’s Journal for 1802.* They showed that a number of salts which they dissolved in water, and placed in contact with the two poles of a galvanic pile, by means of iron or silver wires, were decomposed, the acid being deposited round the positive wires, and the base round the negative pole.† Ammonia was also decomposed — azotic gas separating from the positive pole of the battery, and hydrogen gas from the negative pole. When lime-water was tried, no decomposition of the lime took place.

“In the ‘Philosophical Transactions’ for 1807, an admirable paper was published by Sir Humphrey Davy, entitled, ‘On Some Chemical Agencies of Electricity,’ containing a very minute and complete investigation of the chemical decompositions produced by voltaic electricity. To perceive the full value of this

* Vol. i. p. 115.

† The salts tried were —

Sulphate of ammonia,
Nitrate of ammonia,
Muriate of ammonia,
Phosphate of ammonia,
Borate of ammonia,

Prussiate of ammonia,
Common salt,
Nitrate of potash,
Bisulphate of potash,
Sulphate of potash,
Muriate of lime.

paper, it would be requisite to have an idea of the previous state of our knowledge of this intricate subject. It had been already observed that when two platinum wires, from the two poles of a galvanic pile, were plunged each into a vessel of water, and the two vessels united by means of wet asbestos or any other conducting substance, an acid appeared round the positive wire, and an alkali round the negative wire.

“This alkali was said by some to be ammonia, by others to be soda. The acid was variously stated as muriatic acid, nitric acid, or even *chlorine*. And it was generally admitted that these acids and alkalies were generated by the galvanic action. Sir H. Davy demonstrated, by decisive experiments, that in these cases the acid and alkali were derived from the decomposition of some salt contained either in the water, or in the vessel in which the water was placed. Most commonly the salt decomposed was common salt, and he showed that agate, basalt, and various other stony bodies, which he used as vessels, contained quantities of common salt appreciable by the galvanic action. When the same agate cup was used in successive experiments, the quantity of acid and alkali evolved diminished each time, and at last no appreciable quantity could be perceived. When glass vessels were used, soda was disengaged at the expense of the glass, which was sensibly corroded. When the water into which the wires were dipped was perfectly pure, and when the vessel containing it was free from every trace of saline matter, no acid or alkali made its appearance, and nothing was evolved except the two constituents of water—namely, oxygen and hydrogen,

the oxygen appearing round the positive wire, and hydrogen round the negative wire.

“When a salt was put into a vessel into which the positive wire was dipped, the vessel into which the negative wire was dipped being filled with pure water, and the two vessels being united by a slip of asbestos moistened with water, the acid of the salt made its appearance round the positive wire, and the alkali round the negative wire, before it could be detected in the intermediate space. But if an intermediate vessel, containing a substance for which the alkali has a strong affinity, be placed between these two vessels, the whole being united by slips of asbestos, then a great part of, or even the whole of, the alkali was nitrate of barytes, and sulphuric acid was placed in the intermediate vessel; much sulphate of barytes was deposited in the intermediate vessel, and very little or even no barytes made its appearance round the negative wire. Upon this subject a most minute, extensive, and satisfactory series of experiments was made by Davy, having no doubt whatever respecting the accuracy of the general fact. Indeed this paper of Sir H. Davy constitutes one of the most important contributions ever made to scientific chemistry, and threw a ray of light upon the chemical affinity, which may ultimately produce the most important consequences.

“The conclusions drawn by Davy from his experiments are, that all substances which have a chemical affinity for each other are in opposite states of electricity, and that the degree of affinity is proportional to the intensity of these opposite states. When such

a compound body is placed in contact with the two poles of a galvanic battery, the positive pole attracts that constituent which is negative, and repels the positive. The negative pole acts in the opposite way, attracting the positive constituent, and repelling the negative. The more powerful the battery, the greater is the force of these attractions and repulsions. We may, therefore, merely by increasing the energy of the battery sufficiently, enable it to decompose any compound whatever. Oxygen, chlorine, bromine, iodine, and acids, being negative bodies, are attracted to the positive pole; while hydrogen, alkalies, earths, oxides, metals, and bases of all kinds, being positive, are attracted to the negative pole.*

“Such are the electrical and such the chemical phenomena produced by the voltaic battery.”

This lecture has been extended beyond due bounds, because we wished to present the interesting quotations we have made, in one view, and without division. To the next we shall defer their rigid examination. They are in part correct and partly false, as we shall endeavor to show in the next, and shall make those facts, about which there can be no mistake, subservient to the purposes for which these lectures are published.

* If this view of the subject, which is probably more conformable to truth than the view of Pouillet given on page 497. of his work, be admitted, it will be necessary to modify the explanation of the way in which the electrical currents pass, given on page 531. If oxygen be negative, and hydrogen positive, it is obvious that the positive current will be attracted to the oxygen and must pass through the hydrogen. These currents, by neutralizing the electricity in both bodies, will occasion the separation of the oxygen and hydrogen, and produce the decompositions referred to on page 531.

LECTURE VI.

GALVANISM. — CONTINUED.

THE CHANGES IN ORGANIC AND INORGANIC MATTER.

THE present lecture will be devoted to the application of those facts and principles of galvanism which have been ascertained by our own observations, and those of others, to the further demonstration of the peculiarities of the theory we have assumed.

Upon the subject of the intimate connection which exists between electricity and the chemical changes which are wrought in various substances, we quoted largely in our former lecture — not because we could not have given those ideas in our own language, and thus have appeared to have written original thoughts, but because we wished to insert the *facts* collocated by an author so eminent as Thompson, the regius professor of chemistry in the University of Glasgow, Scotland, in his own language, so that, for minds that demand the authority of great names, we might have a convenient reference in the body of this work, reserving to ourself, however, at the same time, the privilege which we shall ever claim and exercise, of drawing our own conclusions from those facts furnished as the data of our reasonings.

The visible and probably invisible universe is nothing

more nor less than one vast laboratory, in which chemical changes are continually progressing in an infinite variety of forms and modifications. The green mantle of vegetation, which clothes the earth in its beautiful summer vestments, receives its freshness, color, nourishment, and increase from the air and the elementary substances of the soil at its root, by means of a chemical change. The tree of the forest first germinates, next becomes a little delicate twig; further on in its progress we find it a pliant sapling, then it shoots upward with luxuriant, spreading branches, and downward with a firmer and deeper root, and becomes, at length, a stately monarch of the woodland, stubborn and unyielding to the wintry blast. All this progression is effected solely by a chemical change, which transforms the nutriment of the air and soil into wood. Even the solid rock has its infancy, its manhood, and its old age. It begins to grow, increases in solidification and cohesive power, comes to maturity, decays and crumbles again to a substance possessing no power of cohesive attraction at all. All this, too, is effected by the potent agency of a continued chemical change. Even a pearly drop of water, embedded in the deep bosom of the mountains, may harden by chemical agencies, and in process of time, perhaps, form the sparkling diamond.

Now, we assume that it is a proposition capable of rational, abundant, and satisfactory proof, that every one of these chemical changes is wrought by the resistless influences of electricity, or the light and caloric of the sun, as it falls upon and pervades the whole material of the earth, for this light and caloric

of the sun are the same thing, in fact, as electricity, which we hope abundantly to demonstrate in its proper place.

That reasoning or superstructure of argumentation which is built upon the immovable basis of self-evident propositions cannot be overthrown by counter-argumentation. It is perfectly impregnable. It is founded in the inherent nature and fitness of things, which change not, while all else in creation changes.

Upon just such propositions we intend to build the superstructure of our argument, in proof of the assumed position that all the chemical changes are wrought by the direct agency of electricity.

The laws which govern nature are uniform. There is no clashing among them. Were there any, the universe of material systems would exhibit one terrific scene of uproar, confusion, anarchy, and chaos. The proposition that "like causes produce like effects" is self-evident. It cannot be made any plainer to a sane mind by any process of reasoning.

We will now condense into as brief a space as is consistent with a lucid perspicuity the substance of the quotations of the last lecture, correct what is erroneous, and then make such deductions and draw such conclusions as the undeniable facts in the case will warrant. This is the substance :

Bodies in opposite *chemical* states — that is, bodies which have a strong affinity for each other — are in opposite *electrical* states; the elements of all bodies or substances which can be decomposed by electricity are either positive or negative; evaporation does not evolve electricity: it is, however, produced by the

combustion of charcoal, hydrogen gas, and other bodies, and also by vegetation.

The constituent principles of bodies go to the different poles of a galvanic battery, and by the influence of the electric agent water is separated into its elements of oxygen and hydrogen gas, the first of which is negative, and the last is positive.

This is the substance, in brief, of those quotations. With the first fact which they develop, we agree perfectly. The acids are all *negative*, and the alkalies are all *positive*. When brought in contact in the form of solution, a chemical union takes place, by the force of the affinity or the chemical attraction which exists between the two substances. That affinity or chemical attraction which brings the two bodies together, and effects their union into a new compound, depends entirely upon the different ingredients which compose that new compound. The alkali is plus or positive, because, as we have before shown, it is surcharged with more than a natural share of electricity. That electricity is arranged, therefore, with the positive polarity of its ultimate particles outward, as in all surcharged bodies, which emanation outward, as we have demonstrated by the test of infallible experiment, constitutes it an alkali, and gives it an alkaline taste. The acid is minus or negative, owing to its destitution of electricity, which destitution gives, as we have elsewhere abundantly shown, a different arrangement to the ultimate particles of the electric agent, by which arrangement, as in all minus or negative bodies, the negative polarity is presented, which constitutes any substance an acid or gives it its acid taste. Let no

one suppose that this is a mere fanciful hypothesis; for we have already demonstrated that it depends upon an *inherent organic law* of electricity, by an experiment with the galvanic battery, by which it is shown, that if a current be *in* at the tongue and *out* of the finger, where one pole is brought in contact with the one, and the other with the other, it has an acid taste, and if in at the finger and out of the tongue, a strong alkaline taste, proving beyond contradiction that an acid and an alkaline taste depend upon the electrical condition, instead of the condition of inert matter merely, without regard to its electrical state.

This suggests the thought, which philosophers would do well to investigate, whether all tastes, and every shade of taste in ponderable substances, do not depend upon the different modification, or rather the different proportions of the admixture of these two fundamental and essential tastes, rather than upon any inherent organic quality in mere inert matter itself. Reasoning from the admirable uniformity of nature's laws, but without having time, in connection with this work, to demonstrate it, we should draw the confident conclusion that it did. If electricity constitutes an alkaline and an acid taste, *why* not, with the same propriety, the sweet, the bitter, and every other possible shade of taste, simply by the different electric states of bodies? That it does, we believe could be demonstrated by deductions based upon the self-evident proposition "that like causes produce like effects."

There cannot be any mistake about the electric states of the alkalies and the acids. The testimony

of experiment is uniform. The one is always plus, and the other minus, and the degrees of their plus and minus depend upon their concentration. Being plus and minus, they unite when brought together. That union exhibits force, and is attended with the violent commotion of a rapid effervescence, as is familiar to all in the union of tartaric acid and soda. Now, what is that principle of affinity which causes the tartaric acid and soda to unite? Is it anything inherent in the mere particles of inert matter themselves which constitute the soda and tartaric acid? We think not. Upon conclusions drawn legitimately from all analogy we predicate this opinion. Let us examine mere ponderable matter as critically and minutely as we may, and the conviction will be forcibly impressed upon the mind, that it has no such inherent energy — no such self-moving power as to produce a commotion among the ultimate particles of which it is composed so violent as that which occurs when they unite with each other during effervescence. What, then, is that principle of affinity which brings them together, if it be not some inherent power belonging to the particles themselves? It is, without doubt, electricity, for it seems to have a sort of mysterious, indefinable, but yet positive ability to take hold of the particles of ponderable matter, as it were with a tenacious grasp, and, by its own unaided energy, control their movements. We see not how else they are brought into union. But if this be the controlling agent which effects the work, then the process by which the union is accomplished is perfectly plain. There is no incomprehensibility about

it, except what exists in the essential nature and qualities of the wondrous agent itself. The one substance is surcharged, because positive, and the other deficient, because negative. There is, then, upon principles which have been already abundantly explained, an attraction between the opposite polarities of the electric principle, by which a plus and a minus are drawn together. Having, as we have before remarked, a hold, by some mysterious organic law of its essential constitution, beyond the ken of chemical analysis or investigation, upon the particles of ponderable matter, they are attracted along with it, and are thus brought, as we have seen, into a chemical union, and a chemical change is produced. This chemical union and change are nothing more nor less than the simple equalization of a plus and a minus in substances, and by that equalization a single compound substance is formed, very different in the properties of its combination from either of the two out of which it was formed. And why? Simply because it is in a different electrical state. This simple compound, we say, is very different from the two out of which it was formed, in all the properties of its combination; for this is abundantly proven by the fact that a virulent poison may be made harmless by a chemical union, and harmless substances be also made virulent poisons by the same chemical union or chemical change. This is done, in all cases, by simply changing their electrical state, which state can be varied by an almost infinite variety of shades and modifications, constituting color, tastes, motion, poisons, antidotes against poisons, and every other property and quality, which is manifested in

matter, except its bulk, ponderosity, and inherent inertness.

Upon deductions built upon fact and experiment, we believe this to be the *true theory* of *all* chemical changes in matter. Those changes are effected through the sole agency of electricity. The *modus operandi* of such changes may, it is true, be, in a measure, hidden sometimes from the inspection of the most acute, and may not, in a vast multitude of instances, be perfectly apparent; but still abstruseness does not at all affect the reality of that agency. If it can be proven beyond controversy, and beyond the shadow of a reasonable doubt, as it certainly can, that such changes have been affected by such agencies, then it is logical to draw an inference, from that self-evident proposition, that "like causes produce like effects," that *other* changes, whose cause is more obscure from certain circumstances that may surround them, are produced by the same agencies, in accordance with the same laws.

In the quotations which we have made in a former lecture, it will be recollected that Sir Humphrey Davy drew the conclusion, from a great variety of experiments, conducted with the utmost care, that *all* substances which have a chemical affinity for each other are uniformly in opposite states of electricity, and that the *degree* of affinity is exactly proportional to the *intensity* of those opposite states. Now, if *all* substances, according to the test of Sir Humphrey Davy's experiments, which have a chemical affinity, are in opposite electrical states, is not the union, which is effected by means of that affinity, effected

simply, as we have shown, by the attractions of a positive and negative, since the laws of nature are uniform, and since "like causes produce like effects"? Or, in other words, that that chemical affinity which exists between all substances, which will unite, is nothing more nor less than electrical attraction.

There are two ways in which mathematicians prove the truth of their calculations to a demonstrative certainty. The one is by a direct, and the other is by an inverse process of deduction. In the first, by a certain process of calculation or reasoning they arrive at a certain result, and in the other, by taking that result for their premises, and by reasoning or calculating backward, they determine whether that process of deduction, by which they arrive at that result, is, every step of it, correct. By just such a plan of procedure, we can determine the correctness of our previous chain of argument, respecting the phenomena of chemical union. We have, by a process of direct reasoning from cause to effect, come to certain conclusions. We will now, by an inverse process of argumentation from effect to cause, prove whether there be any flaws or broken links in that chain. We have demonstrated, by an allusion to facts with which all are perfectly familiar, that the alkalies and the acids will unite by the influence of chemical attraction or of electrical attraction, which is the same thing. Now, if we can show that these can be separated again, particle from particle, by the same agent that produces their union, then we, by inverse reasoning from effect to cause, prove, beyond the possibility of mistake, that electricity is the efficient agent in the

production of all chemical changes. And this has already been shown in the record of certain experiments contained in the quotations of the last lecture.

It will be recollected by those who read the former lecture carefully that, by the experiments of Berzelius and Hisinger, with a galvanic battery, as described by them in 1802, in Gehlen's Journal, various salts in solution were separated or decomposed, and the acid of the solution was deposited around the positive pole, and the base or alkali around the negative pole, in accordance with an immutable chemical law of the attraction of unlike polarities.

The experiments of Sir Humphrey Davy abundantly confirm those of Berzelius and Hisinger. He found that, by increasing the energy of his battery sufficiently, and with appropriate apparatus for the purpose, he could decompose any compound body whatever, the negatives in all cases collecting around the positive pole, and the positives around the negative pole, thus proving that the electric agent will separate compounds as well as form them, which we have heretofore proved.

A question may here arise as to the correctness of our theory upon the subject of ponderable matter. We have assumed that it is a simple essential principle, and that all its infinite variety of modifications of every kind is caused alone by the imponderable principle, which controls and arranges all its particles as we find them arranged.

Now, this may be denied, from the fact developed by the experiments of the before-mentioned chemists, that one ingredient of a compound in solution goes

to one pole of a galvanic battery, and the other to the other pole. It may, from this fact, and with great seeming plausibility, be argued that the two ingredients, which go to opposite poles, called alkalies and acids, must be matter inherently different from each other, and that, on account of that inherent difference, the separation takes place. Such an inference, however, does not necessarily result from the premises. It can, in fact, be shown to be erroneous. It is not separated into constituent ingredients by any repulsive force which exists within it inherently, because, if such repulsive *inherent* force *did* actually exist, the acids and the alkalies would not, under other circumstances, exhibit an attractive affinity at all, but would forever, and under every possible variety of conditions, exhibit the same stubborn repulsive power; and, therefore, never amalgamate, as they do, when a new compound is formed, by the effervescence of tartaric acid and soda.

This fact, that repulsion takes place under one set of circumstances, and attraction under another, speaks volumes in favor of the validity and truth of the proposition that the alkalies and acids are united as in solution, and separated again, as in the galvanic experiment, *entirely* in both cases by the force of electricity exerted over their particles. This must, in reality, amount to a demonstration, in the view of every mind acutely philosophic.

"But," says the inquirer after true science, "there must be something inherently different in the nature of the particles of the alkalies and the acids themselves, or else the positive pole of the battery would

not attract the acid, nor the negative the alkali, but they would move indiscriminately either way, and not be decomposed at all." This assertion, however, is predicated upon the supposition that a particle that was alkaline before being compounded by a chemical union, is also alkaline when separated by the energy of the galvanic battery. But, at the risk of differing with the whole body of chemists, we shall affirm that this by no means follows as a necessary consequence. It certainly can, with great plausibility, at least, be made a question, whether particles may not move indiscriminately to *either* pole, and there, by the peculiar influences which we know the two opposite poles of a galvanic battery exert over substances in contact with them, and which are confessedly very mysterious, be made either alkaline or acid by that contact. This supposition we know would do violence to the prejudices and prepossessions of many scholars. But why should it? Does not electricity evidently demonstrate that, within its own inherent organic nature, is laid *alone* the basis of the alkalies and the acids, by the experiment upon the tongue with the inward and the outward current of a galvanic battery? This will not be denied, and cannot be, for "facts are stubborn things," which cannot be gainsaid nor resisted. Are they not, also, as we have abundantly shown, both decomposed and recomposed, and therefore controlled by the electric agent, which would not and could not be the case if the two apparently opposite ingredients, which form the compound, were inherently different in their own organic nature, independent of the influence of imponderable matter? Most certainly.

For they would never thus separate and unite again, did the force, which controls these opposing movements, reside within themselves. Besides, it is a fact revealed by both the researches of geology and the experiments of chemistry, that the very same substance, or mass of substances, yea, the very identical ultimate particles of a substance, may change their nature from age to age, by chemical processes wrought upon them.

A substance, for instance, may have been animated flesh and bones, as in the mighty army of Xerxes, when he invaded Greece. That army, having been mowed down upon the battle-field by the victorious invader, may have mingled with the soil upon which they fell, and, by their putrid blood and flesh and crumbling bones, have made the soil luxuriant. Out of it may have shot up a forest upon the desolated waste, and this flesh and blood and bones have been reformed into a grove of stately trees. These trees, in the revolutions of time, may have been swept away and buried by a deluge. There, within the bosom of the earth, they may have undergone another change, and have been reformed either into solid rock, or beds of bituminous coal, to become the subjects of still further and equally remarkable transformations, being burned and resolved into vapors, gases, ashes, and electricity, and prepared to enter, in this state, into the composition of an almost endless variety of other substances. This supposition, which we have made for the sake of illustration, is no fanciful chimera of the brain, but well-authenticated reality.

Geology and chemistry prove that such transforma-

tions have been occurring in all ages, and that they are continually occurring at the present time. And lest it should be said, for the purpose of weakening or attempting to invalidate our argument, that such transformations are never made of a substance, except the new formation be of the same nature as the old one out of which the new was organized, and that a combustible furnishes the material for a new combustible formation—as wood and other vegetable matter, for instance, form bituminous coal—we would reply that such an assumption is proven false entirely, by the transformation of wood into that kind of stone of the hardest and finest quality which is called “the hone,” by depositing the wood a few years in one of the lakes of Ireland.

We might extend our remarks upon the subject of the chemical changes of the character spoken of, until they should fill volumes, for they are almost infinite in variety. But sufficient has been already said to prove to a demonstration, from the data of incontrovertible facts, that the forces by which chemical changes are wrought in ponderable matter do not reside inherently in the substances themselves, or belong to their organic nature; for if they did thus reside, we hold it to be a proposition capable of the clearest and most logical demonstration, that no such transformation of substances could ever possibly occur, but there would then be one changeless, unvaried scene, where now all is variety and ceaseless mutation.

We now leave this branch of our subject, with the feeling, however, that much more might be said, had

we time and space, and that what we have said might have been vastly more appropriate, had we the ability of some, to whose attainments we presume not to aspire. In a subject as abstruse as that of the principle of chemical affinities, it must be expected that very many things will be passed over without being made perfectly plain and intelligible to all. Our object has been mainly to seize upon strong positions of lucid proof, where there could be no mistake or deception in our reasonings, or evasion of their propriety by others, and then from such strong positions draw reasonable and logical inferences respecting subjects more abstruse and difficult.

The electrical condition of oxygen and hydrogen gas—and more particularly of oxygen—we shall now consider minutely, because it is, as we shall show, the most essential agent in chemical changes that exists.

There are, in the quotations which we made in the last lecture, two clashing theories respecting the relative electrical state of those two gases.

M. Pouillet, a distinguished chemist, by a variety of experiments, very carefully conducted, as we have seen in the quotations of the last lecture, came to the conclusion that oxygen gas was positive and hydrogen negative.

Sir Humphrey Davy, on the contrary, from the test of experiment, came to the conclusion in the same quotations that oxygen is negative and hydrogen positive.

With this opinion of Davy, Mr. Thompson, who collocated the testimony of the two, and from whose

valuable work we made the extracts, seems to coincide.

Now, when such men of deep and careful research, and critical intellectual acumen as Pouillet, Davy, and Thompson *disagree*, and take positions directly opposed to each other, what shall we do to determine which is right and which is wrong, for right *both* certainly cannot be? Why, examine critically the positions of each, according to the best light we have, and endeavor, if possible, to ascertain where the *error* lies.

The first subject of investigation is oxygen, which, as we said before, is a very essential agent in the chemical changes which are continually occurring throughout nature.

This gas was discovered by Dr. Priestly, in 1744. There have, since its discovery, been given several appellations, indicative of its nature. Priestly called it dephlogisticated air. It was called *empyreal air* by Scheele, and vital air by Condorcet. Lavoisier gave it the name which it now bears, derived from two Greek words, which signify *to generate acid*, from its being considered by him the sole cause of acidity.

This gas is colorless, has neither taste nor smell, is heavier than atmospheric air, has not, by any experiment hitherto made, been decomposed, is a non-conductor of electricity, emits both light and heat by the force of sudden compression, and, according to the opinion of some, is the most negative electric in existence, always appearing at the positive pole when any compound which contains it is exposed to

the action of galvanism, which opinion we shall, however, endeavor to show is entirely unfounded.

Oxygen has a very powerful affinity or attraction for most simple substances, and, indeed, it may be made to combine with all. By such combination, it oxidizes or corrodes the metals, which oxidation is a species of combustion. It is also the sustaining principle of fire; for the sole reason why fuel burns freely in the open air, or is smothered by cutting off its communication with the atmosphere, is because, in the one case, its ignition is sustained by its affinity for oxygen, which it attracts from the air, and in the other it is deprived of an appropriate supply to produce the chemical change of vegetable oxidation.

All substances which will burn in the open air will deflagrate much more rapidly and brilliantly in oxygen. If there be the least perceptible spark, for instance, upon a piece of wood, it will instantly burst into a fierce blaze when inserted in a jar of this gas. And even steel and iron will burn with rapid and intense brilliancy when thus inserted. The moment, however, that the oxygen is exhausted by chemical combination with the burning body, the ignition ceases, although the substance may not have been entirely consumed.

There are other interesting phenomena still, which will illustrate the nature of oxygen gas. It seems to be an absolutely essential agent in respiration. No animal can live by inhaling an atmosphere which does not contain a certain portion of oxygen, uncombined with other substances; for he will die very soon if

forced to breathe the air out of which the oxygen has been entirely extracted. If a lighted candle or taper be immersed in it, its flames will be extinguished. Respiration and combustion therefore require the presence of the same sustaining agent. An animal cannot live in an atmosphere which is unable to support combustion; nor, in general, can a candle burn in air which contains too little oxygen for respiration.

There is another singular property about oxygen. Although a certain portion of it is absolutely necessary to sustain respiration, yet an unmixed atmosphere of pure oxygen is as fatal to life as its destitution, though not so speedy in its effects. "When an animal, as a rabbit for instance, is supplied with such an atmosphere, no inconvenience is at first perceived, but, after an interval of an hour or more, the circulation and respiration become very rapid, and the system in general highly excited; symptoms of debility subsequently ensue, followed by insensibility, and death occurs in six, ten, or twelve hours. On examination after death, the blood is found highly florid in every part of the body, and the heart acts strongly even after the breathing has ceased."

From the facts described above, these are the influences, in substance, of oxygen gas. It is the prime agent of the oxidation of all metals, the great supporter of combustion, and gives vitality, warmth, and purity to the blood, as it circulates through the system.

Now, are these the influences of a negatively electrified body? Will a substance which is minus aid

in sustaining flame, while one that is plus puts it out? Is there anything in the inherent nature of positive electricity to produce such a result? Is it either a principle of cold or dampness, that it should extinguish fire or chill the blood during respiration? It seems to us that any one who understands the nature of the electric agent can be at no loss for a ready answer. Even plain, unlettered common sense, could hardly fail of coming to a correct conclusion. Such properties as belong inherently to oxygen gas, and such agencies as it exhibits, beyond controversy or the possibility of mistake, in contact with various substances, are entirely inconsistent with the properties and the agencies which we know belong to negative bodies. Carbonic acid gas, for instance, is a negative body. Does it sustain combustion or respiration, as, reasoning from analogy, we should suppose it would? No; but its influences are directly the reverse of those ascribed to oxygen gas. Instead of sustaining the ignition of fuel, it immediately extinguishes flame, and instantaneously stops respiration, instead of promoting it. Now, if the maxim, that "like causes produce like effects," be a self-evident proposition, as it doubtless is, *can* oxygen gas and carbonic acid gas be *both* negative bodies, when the inherent properties and agencies of the *one* are directly the antipodes of the *other*? The conclusion that they are, must, it appears to us, be considered, when viewed in the light either of sound logic or unlettered common sense, as preposterous in the extreme. The fact is Pouillet was right, and Davy and Thompson, his opponents in theory, were wrong. Oxygen gas *is*

positive, for no agent can exhibit the same influences without being positive, if there be any certainty at all in the source of our chemical knowledge.

The further discussion, however, of this interesting and important subject must be deferred to the next lecture, where we hope, by an array of facts and arguments, to prove conclusively that oxygen gas is positive, and also satisfactorily reconcile those phenomena with this theory, where it may seem to be negative.

LECTURE VII.

OXYGEN AND HYDROGEN.

THIS lecture will be a continuation of the description of those facts connected with electricity which have been developed by galvanism, and by experiments in other departments of chemistry, as well as an examination and exposure of falsities in theory.

The first subject of attention and remark will be oxygen gas. We have already, in a former lecture, described some of its most essential agencies, and endeavored to show, by conclusions drawn from both reason and analogy, that those agencies were entirely inconsistent with the idea of a negative body, for we could not see what principle there was in mere negative electricity, or a mere absence of it, to support combustion, so as even to make iron and steel deflagrate with intense brilliancy, or how it should, as we shall endeavor to prove that it does, impart vitality and warmth to the blood, supply fuel for that steam-engine of organic life, the heart, and enable it to propel the purple current with such force through all the channels made for its circulation through the system. As the opinions of Davy and Thompson upon this subject were, beyond the shadow of a reasonable doubt, incorrect, and as they clashed with the conclu-

sions to which Pouillet came, by experiments equally cautious and critical, it may be well to examine the premises from which they drew their conclusions, and see if they have not mistaken them in some very essential matters.

By a reference to a record of their experiments, it will be perceived that the foundation of their mistake might have been in the supposition that certain phenomena, attending the decomposition of unmixed water, and of salts of various kinds in solution, with the galvanic battery, must be precisely analogous. They had ascertained that, in such decompositions, by the action of galvanism, chlorine, bromine, iodine, and acids were attracted to the positive pole, while the alkalies, earths, oxides, metals, and bases of all kinds were attracted to the negative pole. By means of the delicate test of the condenser, they had ascertained that the first class of substances enumerated were negative, and the other positive, and that the chlorine, bromine, iodine, and acids were attracted to the positive pole by the mutual attraction of what, according to their theory, they considered unlike electricities, but which we consider unlike polarities of one agent, and that the alkalies, earths, oxides, metals, and bases were attracted to the negative pole by the operation of the same law. By like experiments, they also ascertained that oxygen gas was attracted to the positive pole with just as much certainty and uniformity as the acids, or any other bodies of the most negative character, and that the other constituent of water, the hydrogen gas, with as much certainty and uniformity was attracted to the negative

pole, like the alkalies or the most positive bodies. They therefore concluded, and very plausibly too, that oxygen was negative, and the hydrogen positive, since they obeyed the same law precisely as other positive and negative substances.

In such a plausible conclusion consists their error, if in error they really were, and that they were is perfectly evident, since the agencies of oxygen gas are different from those of any known negative, and just such as we should, at a glance, conclude were positive.

But, if we deny the correctness of their conclusions, we are bound to show, if possible, wherein that error consists. This, we are aware, will be very difficult to do to the satisfaction of those who may have stubborn prepossessions to overcome. Yet we by no means despair of convincing even those, except there be some among them who consider great names a sufficient demonstration of the truth of a proposition which they may advocate, no matter how lame may be their arguments, nor how contrary to fact their reasonings.

If oxygen gas be positive, why does it disobey that law which, as we have seen, regulates all positive substances, and go to the positive pole, instead of going to the negative, as they all do? Simply because it is a *cause* instead of an *effect*, as in the other cases alluded to. It is electricity, instead of an *effect* merely of electricity.

The acids, being negative, move to the positive pole, because opposite polarities, according to the inherent laws of opposite polarities, bring them there. But oxygen rises from the positive pole for *another* reason,

essentially *different*. It is constituted by the positive current itself, instead of being collected and constituted by any mere *effect* of that current, and rises, therefore, from its own pole, instead of moving to the negative pole, and there rising. This we conceive to be the *only* rational and plausible, and indeed the only *possible* reason why oxygen, if positive, is uniformly found at the positive pole of the battery, while all negatives move there according to the laws of electrical attraction; for, unless it be, as we have assumed, *electricity itself*, instead of any *effect* merely, no reason could be assigned for its moving to that pole, except it were negative, which, as we have already shown, cannot, in accordance with the uniformity of nature's laws, be correct.

"But," says the objector to this proposition, "electricity, or galvanism, is an imponderable principle, which exhibits no perceptible weight at all, but oxygen gas is a substance, more dense than most gases, and heavier even than atmospheric air."

That we acknowledge is true. It is heavier than the atmosphere, and electricity exhibits no weight at all that can be detected by the very nicest and minutest balances. But does this disprove our solution of this apparent anomaly? By no means. It may contain the plus current of the battery, which, however, in its action upon the water, collects to itself certain weighty constituents of that water, which it forms into the vehicle or medium in which it is borne, the same as vapor, which is an association of mere vesicles, formed of certain constituents of water, enclosing caloric, the generating agent, which, by the way, will illustrate

the formation of oxygen gas. During the generation of vapor by caloric, no positive electric effects are perceptible, according to the testimony of M. Pouillet and Thompson. In this case, caloric is the *cause* of the vapor, arranging for particular use the watery constituents of the vesicle in which it encases itself, and becoming invisible and imperceptible during that encasement. When, however, by the proximity of any chemical attractions or affinities which call it forth from its encasement into visibility, and make it burst the vaporous vesicle which it had formed for itself, it then exhibits the phenomena of positive electricity distinctly and strongly marked, as we shall abundantly show when we come to the cause of the nimbification and electrical discharges of the storm-cloud.

Now, what caloric does for itself, in the formation of its vaporous vesicle, we consider that the positive current of the galvanic battery does for itself in the formation of an encasement for itself, out of certain dense and weighty ingredients of the water—which cause, together with its encasement, constitutes that heavy, invisible, vaporous air which we call oxygen gas.

While thus encased, its positive properties, like the creating agent of the vapor of water, are imperceptible, and are never revealed, except when certain strong chemical affinities or attractions call it forth from its imperceptibility, and make it burst asunder the encasement in which it had hidden itself, and show the resistless energies of its nature.

In this way, and in this *alone*, it seems to us, can the appearance of the positive oxygen at the positive

pole of the battery be accounted for, when all other positive substances go to the negative pole. It is a *cause* rather than a *result*. It is positive or plus electricity, so encased as we have described, rather than any effect in the same sense, as the collection of an acid around the positive wire can be considered an effect.

Oxygen gas has, ever since its discovery by Priestly, been considered a simple substance, and been thus classified. But the reason of this is, because no chemist has yet been able to decompose it, and demonstrate that it is a compound. There can, however, be no doubt as to its being a compound body, if electricity, in combination with certain ingredients of ponderable matter, can be called a compound body. This is proven by the fact that, although chemists have not been so fortunate as to succeed in decomposing it, it has been decomposed, and is continually undergoing a process of decomposition in that natural chemical laboratory — far more perfect than any artificial one possibly can be — *the lungs*, as we shall show abundantly in another connection.

Now, the reason why chemists have not succeeded in decomposing this agent, and resolving it into its elements, is, we presume, owing to the fact that the essential or causating principle is so very subtle that it cannot be controlled, and so very powerful that its attractions for its encasement resist all the counter attractions which chemists have arrayed around it.

Hydrogen gas, which is the opposite of oxygen, will now be briefly examined for a little while, and afterwards we shall remark upon some influences

of both in connection, which will further illustrate this subject.

This gas was formerly called *inflammable air*, from its supposed combustibility, and *phlogiston*, from the supposition that it was the matter or principle of heat. But its present name is compounded of two Greek words, which signify to *generate water*, from the fact that, when changed by combustion, it constitutes water.

As we are obliged, in support of the proposition that hydrogen is negative, to examine the subject critically, and to show the falsity of prevailing theories upon the subject, we shall first quote the language of a celebrated author, and then examine those sentiments for ourselves. Here follows an extract from Turner:

“Hydrogen is a colorless gas; when pure, has neither odor nor taste, and is a powerful refractor of light. Like oxygen, it cannot be resolved into more simple parts, and, like that gas, has hitherto resisted all attempts to compress it into a liquid. It is the lightest body in nature, and is consequently the best material for filling balloons. From its extreme lightness it is difficult to ascertain its precise density by weighing; because the presence of minute quantities of common air or watery vapor occasions considerable error.

“Hydrogen does not change the blue color of vegetables. It is sparingly absorbed by water, one hundred cubic inches of that liquid dissolving about one and a half of the gas. It cannot support respiration — for an animal soon perishes when confined in

it. Death ensues from deprivation of oxygen, rather than from any noxious quality of the hydrogen — since an atmosphere composed of a due proportion of oxygen and hydrogen gas may be respired without inconvenience. Nor is it a supporter of combustion, for when a lighted candle, fixed on wire, is passed up into an inverted jar full of hydrogen gas, the light instantly disappears.

“Hydrogen gas is inflammable in an eminent degree, though, like other combustibles, it requires the aid of a supporter of combustion. This is exemplified by the experiment above alluded to, in which the gas is kindled by the flame of a candle, but burns only where it is in contact with the air. Its combustion, when conducted in this manner, goes on tranquilly, and is attended with a yellowish-blue flame and a very feeble light. The phenomena are different when the hydrogen is previously mixed with a due quantity of atmospheric air. The approach of flame not only sets fire to the gas near it, but the whole is kindled at the same instant; and a flash of light passes through the mixture, followed by a violent explosion. The best proportion for the experiment is two measures of hydrogen to five or six of air. The explosion is far more violent when pure oxygen is used instead of atmospheric air, particularly when the gases are mixed together in the ratio of one measure of oxygen to two of hydrogen.

“Oxygen and hydrogen gases cannot combine at ordinary temperatures, and may, therefore, be kept in a state of mixture without even gradual combination taking place between them. Hydrogen may be set

on fire, when in contact with air or oxygen gas, by flame, by a solid body heated to bright redness, and by the electric spark. If a jet of hydrogen gas be thrown upon recently prepared spongy platinum, this metal almost instantly becomes red-hot, and then sets fire to the gas, a discovery which was made in the year 1824, by Professor Doebereiner of Jena. The power of flame and electricity, in causing a mixture of hydrogen with air or oxygen gas to explode, is limited. Mr. Cavendish found that flame occasions a very feeble explosion when the hydrogen is mixed with nine times its bulk of air; and that a mixture of four measures of hydrogen with one of air does not explode at all. An explosive mixture, formed of two measures of hydrogen and one of oxygen gas, explodes from all the causes above enumerated. Biot found that a sudden and violent compression likewise causes an explosion, apparently from the heat emitted during the operation; for an equal degree of condensation, slowly produced, has not the same effect. The electric spark ceases to cause detonation when the explosive mixture is diluted with twelve times its volume of air, fourteen of oxygen, or nine of hydrogen; or when it is expanded to sixteen times its bulk by diminished pressure. Spongy platinum acts just as rapidly as flame or the electric spark in producing explosion, provided the gases are quite pure and mixed in the exact ratio of two to one.* Mr. Faraday

* For a variety of facts respecting the causes which prevent the action of flame, electricity, and platinum in producing detonation, the reader may consult the essay of M. Grotthus in the *Ann. de Chimie*, vol. lxxxii.; Sir H. Davy's work on flame; Dr. Henry's essay in the *Philosophical Transactions* for 1824; and a paper by myself in the *Edinburgh Philosophical Journal* for the same year.

finds that platinum foil, if perfectly clean, produces gradual though rather rapid combination of the gases, often followed by explosion. ('Philosophical Transactions,' 1834.)

"When the action of heat, the electric spark, and spongy platinum no longer cause explosion, a silent and gradual combination between the gases may still be occasioned by them. Sir H. Davy observed that oxygen and hydrogen gases united slowly with one another, when they are exposed to a temperature above the boiling-point of mercury, and below that at which glass begins to appear luminous in the dark. An explosive mixture, diluted with air to too great a degree to explode by electricity, is made to unite silently by a succession of electric sparks. Spongy platinum causes them to unite slowly, though mixed with one hundred times their bulk of oxygen gas."

In the examination of this subject, and in commenting upon the facts developed and the positions taken in the extract, we shall do it in the order in which they occur in that extract.

It is said that "hydrogen gas cannot support respiration." And why not? It is affirmed that it is not because it contains any deleterious quality, but because it is simply deficient in oxygen. We grant that all this is true. It will not support respiration, and consequently life, when unmixed with oxygen, simply for the want of that oxygen.

Now, what is there in the oxygen, and not in the hydrogen, which supports respiration and life? We affirm that it is *positive* electricity, with which the oxygen is charged, and of which the hydrogen is

almost entirely deficient. By examining the phenomena of respiration in the strong light of the facts which chemistry throws upon the subject, we shall be convinced that this is the case. What are the phenomena of respiration?

When atmospheric air is drawn into the lungs by inhalation, a remarkable chemical change takes place, through its influence upon the dark venous blood in its passage through the lungs, where, in the innumerable veins and air-cells, it comes in contact with the atmosphere. The oxygen of the atmosphere is decomposed, the imponderable principle of the oxygen, or its electric cause, enters into the blood, neutralizes, by a chemical change, certain deleterious properties, which, if retained in the blood, would destroy life; the ponderable encasement of the imponderable principle, whatever that encasement be, is exhaled again, the blood changes from a dark purple to a florid red color, in part by being unloaded of its carbonic acid gas, and the streams of life are purified from all stagnating causes and qualities, vivified and filled with their vital and energizing warmth, by the electricity infused into them. Is not this, in brief, the reason why oxygen gas is necessary for the support of life? Is not animal heat, or the heat and consequent fluidity of the blood, caused by the positive electricity contained in it? Is not this, in fact, the principle of mere animal life, since the blood is that animal life? Were this gas *negative*, could its effects upon the blood be such as we find them? Could a *negative* body impart *heat* at all, since the absence of electricity is the absence of the *essential*

principle of fire or heat? The appropriate answer to these questions is perfectly obvious. All must, we think, from these facts and reasons, conclude that oxygen is, and *must* of necessity be, *positive*, and hydrogen is consequently *negative*, since it is the very opposite of oxygen. But there is still further proof to be drawn from the extract itself.

Some there may be who may still affirm, with the books, that hydrogen must be positive, since it is known to be "inflammable in an eminent degree," in the language of the extract from Turner, and, therefore, contrary to the assertions above, it must contain the principle of fire. But chemists have been entirely at fault in this position. The fact is, it is *not inflammable at all*, which fact is capable of such lucid and perfectly logical demonstration as must satisfy every ingenuous and unprejudiced mind.

Although hydrogen is affirmed to be inflammable, yet it is said in the same breath that it is "not a supporter of combustion," which is a palpable contradiction in terms. Can any substance contain the principle of fire, or be combustible, without having at the same time the power to sustain combustion? The thing is impossible. "When," in the language of Turner, "a lighted candle, fixed on a wire, is passed up into an inverted jar full of hydrogen gas, the light instantly disappears." Now, why is this? If hydrogen were *inflammable*, would it put *out* fire? The idea is perfectly absurd. One might just as well, and with just as much reason, affirm that fire would put out fire, as to affirm that an inflammable gas would put out fire.

To show the difference between the two gases, if a lighted candle be inserted in a jar of hydrogen, it will be extinguished; but if there be the least spark or smoke at the end of the wick, and it be inserted in a jar of oxygen, it will be instantly relighted, and so, by inserting the candle alternately in hydrogen and oxygen, it will alternately be put out and relighted, until the two gases escape, or the candle is consumed. Now, which appears, by this experiment, the most like a *positive* gas, hydrogen or oxygen? The one extinguishes flame, and the other relights it. Which, then, seems to be *inflammable*? Common sense can answer that question, and this must be its answer: That substance must be *inflammable* which will aid to burn a body, instead of extinguishing it when on fire.

But the question may here be asked why hydrogen gas will burn, as in the cases enumerated in the extract we are considering. We answer unhesitatingly that it will not burn at all, that it never did and never will. It will inflame, it is said, by the application of a lighted candle, when in contact with atmospheric air, which contains oxygen, or else in contact with pure oxygen itself. But why is this? Why must it come invariably in contact with a *supporter* of combustion? Simply for this reason. The hydrogen is negative and the oxygen is positive. That positive contains the principle of fire, or electricity, and is, therefore, a supporter of combustion. The negative is the entire absence of the principle of fire. The one is therefore highly plus, and the other deeply minus, and when they are mixed, either by contact with the atmosphere, or with a certain proportion of the two gases pure,

they unite upon the application of flame with an explosion. This union and explosion are precisely in accordance with the known principles of electrical attraction. Between the two there exists the strong affinity of opposite polarities. The plus of the one is given out to the minus of the other, and this combustion is the result. But the fire depends, not upon the hydrogen, but upon the oxygen, for when it gives out its plus to the minus of the hydrogen, in the effort to restore an equilibrium between two opposites, that plus charge appears in the form of fire. This, and this *only*, it appears to us, is the cause or reason of the combustion, and must prove conclusively that oxygen is highly positive, while hydrogen is deeply negative. There cannot possibly, it seems to us, be any rational doubt about it.

There is another fact still in the extract, which, if left unexplained, may lead to false conclusions. It is this: "If a jet of hydrogen gas be thrown upon recently prepared spongy platinum, this metal almost instantly becomes red-hot, and then sets fire to the gas." Now, this question may occur: if hydrogen be not *inflammable*, and if it contain not the principle of heat, how can it make the platinum *red-hot*? This question we shall answer by denying that any such effect is caused by the hydrogen simply. There is another way to account for the phenomenon — a way in more strict accordance with the known laws of chemistry. Platinum is a positive substance, and is so classed in the list of positive substances, and hydrogen is negative, as we have seen. Now, when a jet of this gas is thrown upon the spongy platinum, why

does that metal become red-hot, unless the positive charge of the hydrogen make it so? This is the *philosophical* solution of the question. The hydrogen, being deeply minus, while the platinum, in comparison, is highly plus, the electricity or latent caloric of the metal rushes to its surface, where, by strong chemical affinities, a deeply minus substance calls it out and makes the plus substance red-hot by its own latent caloric becoming visible. This is the law precisely of all *galvanic* action, and indeed of all *chemical agencies* whatever. A metal can be affected or decomposed in *two* ways. If a substance, highly plus, be brought, in solution or in the form of a gas, in contact with the metal, so as to have the facility, by that contact, of taking hold of its particles, the plus substance will decompose the metal more or less rapidly, in exact accordance with the difference in the respective amounts of latent caloric or electricity which they contain.

If this position be correct, as it doubtless is, then we have a correct solution for the action of the galvanic battery. When the associated plates of zinc and copper, composing the battery, are plunged into a strong solution of nitric acid, the zinc plate is attacked by the acid, instead of the copper. And why? Because it is more positively charged than the copper. Rapid decomposition of the zinc is the consequence. And why? Because, it being plus and the acid minus, the latent caloric of the zinc, or its electricity, which makes it plus, *burns* its way out through the metal to the deeply negative body which surrounds that metal, and thus decomposition takes place;

latent caloric is set free by burning up the metal in its passage to the minus substance, for which it has a stronger affinity, and during this change a portion of it escapes by the conducting poles of the battery.

The acid would act upon the copper in the same way it does upon the zinc, were it associated with some other metal which should be *relatively* minus, or have less latent caloric than itself. This is proven from the fact that, although the solution of nitric acid will not materially affect the copper when associated with the zinc, yet, when the same acid is poured upon the copper by itself, the copper is rapidly consumed, the latent caloric burns its way out to the minus acid, and during the decomposition, which is attended with no small commotion, a purple vapor rises, which has almost the appearance of flame.

But oxygen gas corrodes or burns, or decomposes the metals for a reason just the *reverse* of that which we have assigned for the action of the acids upon them. It is highly positive or plus, and, therefore, imparts its latent fire—caloric or electricity, just which you please to call it—to the metals, instead of receiving it *from* them, as the acids do, when in contact with them. The consequence is that it burns them to ashes silently, as in the corrosion or oxidation of the metals exposed to a damp atmosphere, or with an intensely brilliant corruscation, as in their deflagration when inserted in a jar of pure oxygen.

We dismiss this subject of the various influences and agencies of oxygen and hydrogen, but more particularly of oxygen, not because it has been exhausted by any means, nor because it could not be extended

with interest, — for there could be a volume written without exhausting it, — but because the design and limits of this work will not permit. Enough, however, has been said, we think, by way of argument and proof, to demonstrate to the perfect satisfaction of every mind that is willing to be satisfied, that oxygen gas is positive, and hydrogen gas is negative, and that the opinions of Pouillet upon this subject were right, and those of Davy and Thompson were wrong. Enough has also been said to show conclusively that electricity is an essential agent in the chemical changes which we witness around us, and which are continually occurring throughout nature, and to prove that the actual cause of many of the wondrous phenomena which come under the observation of chemists has been mistaken.

In our next lecture we design to show, among other important facts, what an essential agent electricity is in the preservation of health, and how, in some cases of disease, it may be of very important service in counteracting the influences of that disease upon the system, and in giving tone and vigor to a debilitated constitution.

LECTURE VIII.

ANIMAL ELECTRICITY AND ELECTRIC PATHOLOGY.

AS intimated in a former lecture, we intend, in the present, to examine the chemical effects of electricity in another important department, perhaps the *most* important of human knowledge, into which we have not, as yet, introduced the reader. We feel, as we enter it, our incompetency to do anything like justice to the subject, for the agencies of electricity in the production of animal life, its indispensable necessity in the preservation of that life, and its remedial qualities, open a vast field of most interesting investigation before us — a field hitherto but little explored — a field, every part of which is full of such marvellous interest, that the Psalmist very properly exclaims, when contemplating it, “I am fearfully and wonderfully made.”

If, in passing from the contemplation of inorganic matter to organic, we range through the various departments of the vegetable kingdom, and the lower order of animated existences, we find that the electric agent, or caloric — which we shall hereafter prove is the same thing — is the grand *instrumental* cause of the germination of life. No acorn ever burst its shell and rose into a stately monarch of the forest — not

one of the ten thousand various seeds of trees, of herbage and of flowers, that clothe and variegate the landscape, ever vegetated without the agency of heat. They would forever have lain dormant and lifeless in the cold and withering embrace of the earth; and, unwarmed into life by the genial influences of the caloric of the sunlight, this globe would have been covered with a chilling desolation, as blank as that of an iceberg, and no more vegetation would have adorned it in a vesture of green than would now spring up on the snow-banks of a December in Nova Zembla.

When we pass from the vegetable to the *animal* kingdom, we find the same great truth illustrated by a thousand facts. What generates life in the egg of the feathered tribe, and sustains and fosters it from the mere incipient embryo of existence to the bursting of the shell by the little chick, as he starts into animation from his prison-house? Why, *caloric*, and *caloric alone*. If the hen, or any other animal of the feathered tribe, fails to brood over the eggs with unwearied constancy—if, during any portion of the gradual stages of the progression of existence, from the incipient enlargement of the impregnated ovary to the period when the shell is burst, the egg be left to cool below the equal temperature of animal heat, it becomes addled immediately, and the principle of animation departs. Even where there is no incubation of the animal, the egg is still hatched by the agency of caloric. The ostrich buries hers in the sands of the desert in the Torrid zone, where she leaves it to be warmed into life by the influences of a

vertical sun. The serpent of the same zone, it is said, follows the example of the ostrich, and, by the germinating power of the heated sand-hills, peoples the burning wastes of Sahara with her venomous brood. Even that industrious little spinster, the silkworm, that fabricates from leaves the imperial robes and vestments of monarchs, is brought into life by a similar process — by the application to the ovum of either natural or artificial heat.

But, although it may here be confessed that caloric is absolutely necessary to the production of those forms of existence to which we have alluded, yet it may be denied that this acknowledged generating agent is electricity, as we have affirmed. Leaving our main argument in proof of the position we have assumed until we come to the subjects of solar light and heat, we would here ask, if caloric and electricity be not inseparable? Was there ever a distinct electrical phenomenon of any kind developed to the observation of chemists, or of anybody else, without the distinct development, at the same time, of a corresponding amount of heat? or, more properly speaking, is not the electricity developed, in fact, nothing more nor less than the caloric which is inseparably attendant upon every such development?

Friction is one of the main causes of the production of electricity. If amber, for instance, be rubbed, or a stick of sealing-wax, they immediately become electrically excited, and will prove it by attracting to themselves contiguous light bodies. This is the case with a glass tube, or any other electric, when rubbed with dry silk or woollen cloth. It is a fact well

worthy of attention and remark that *heat* is invariably produced by that friction. Now, are not the electrical phenomena, which are manifested by that friction, owing entirely to the latent caloric which is called out, and made visible, since it is ever developed by the exciting cause? Let us examine the catalogue of electrical facts, and see if we do not find still further confirmation of the proposition we have assumed, and sufficient to convince the sceptical.

According to the experiments of M. Pouillet, already recorded in this work, the gas that rises from burning charcoal is positively electrified. What is that but the evolution of caloric in a certain form?

By heating metallic rods at one end, and thus disturbing the equalization of their temperature, electric or magnetic phenomena make their appearance; for one end of such rods will be positive, and the other consequently negative, as is exhibited plainly by their attractions and repulsions of the electrometer or magnetic needle. Here the character of the electrifying agent is so perfectly apparent, that there can be no mistake at all about it. It is caloric, and nothing but caloric.

The galvanic battery in action always produces heat. If the acidulated solution, into which the battery is plunged, is perfectly cold at the time of its immersion, that solution will be heated so rapidly that it will, in some cases, actually boil in less than three minutes. Now, what causes this great and sudden change in the temperature of the solution, except it be the latent caloric of the zinc set free by the process of the combustion of the metal, heretofore

described, and which constitutes the galvanic current, and produces the galvanic effects of the battery? We feel that candid minds must be irresistibly brought to the same conclusion by these facts. That caloric which heats the solution *must* be the electric agent, and that electric agent the caloric. There can possibly be no mistake about this.

All crystallizations of salts, and other crystallizations of whatever character they may be, exhibit electrical phenomena, and are always attended with the evolution of caloric. All freezing mixtures expel caloric rapidly, and evolve also electricity. According to the estimate of Dr. Hare, of Philadelphia, the crystallization of vapor which attends a snow-storm gives out more caloric than a shower of red-hot pulverized glass, and we know that such crystallization of vapor is accompanied with electrical phenomena.

The further elucidation of the identity of caloric and electricity will be referred to in its appropriate place — the discussion of the subject of solar heat — since in this connection it is rather a digression from the topics we had selected. We shall there collocate, we think, such a formidable array of additional facts as must convince the most sceptical unbeliever. But enough has been said, we presume, to prove that the caloric, which is the cause of the germination of all seeds, and the principle which vivifies the embryo of the egg, is electricity, and produces these effects by the known chemical influences of that agent.

With the single remark that, if the subject be closely scrutinized, it will be apparent to every one that the reproduction and continuation of every species

of animals, as well as vegetables, are owing to an *electric cause*, we pass on to the consideration of other important topics connected with this subject.

Having shown that caloric or electricity is the generating agent of mere animal life, we shall now endeavor to show that it is a more essential agent in the continuance of that life, and in the preservation of health, than we have, at a superficial glance, been apt to imagine.

Health we consider to be the equilibrium of the electrical condition of the human system, for instance; and the more perfect that equilibrium, the more perfect the health.

Disease, on the contrary, is either a plus or a minus of the whole system, or else an unequal electrical condition of the system, making one part plus and the other part minus, and thereby causing obstructions and stagnation of the vital fluid.

We will, for a moment, examine into the condition of the human system when minus, and ascertain whether the facts in the case will sustain our theory.

What are the phenomena, for instance, attending the distressing complaint of diarrhœa, cholera morbus, or Asiatic cholera? The system is in a deeply minus condition. The surface is cold; the blood scarcely circulates in the external channels of its passage, or in the veins, leaving the extremities in a chilled condition; the skin assumes a bluish cast; no perspiration starts from the system; but if there be any moisture, it is a cold, clammy suffusion, the same as dew. Having left the surface and extremities, the vital current rushes with tremendous pressure upon

the heart and main internal arteries; the delicate membranous coatings of the stomach and alimentary canal become turgid and inflamed, and, in some cases, raw, ulcerated, and suffused with blood; the breathing is labored, as though the lethargies of a nightmare pressed upon the vital apparatus; the breath becomes hot and scalding; and death makes rapid and giant strides upon the debilitated constitution.

Now for an explanation of the chemical cause of this condition of the system. It will be found, upon the closest scrutiny, that in ninety-nine cases out of a hundred, when the above symptoms make their appearance, the stomach is filled with a cold, slimy, ropy, indigestible load, which is, of course, a deeply minus or negative substance. Now what are the *chemical* consequences of this negative substance upon the system? They are deleterious in the extreme, as will be explained by a reference to an experiment in a former lecture. It will be recollected that we demonstrated that, if a current of galvanism be passed *in* to the tongue, it produces an acid taste in the mouth. This proves that an inward current of electricity is, in some mysterious way, the generator of acidity, which, as we have shown abundantly in another connection, is the reason why all acids are minus bodies.

The contents of the stomach, being minus or acid, will, of course, have an attraction for the plus or alkaline polarities of electricity, and the current will therefore be *inward* from the surface, which will be left cold, while those burning alkaline polarities will irritate the internal coats of the stomach and intes-

tines, the same as they are irritated in the cholera and other kindred diseases, and produce, according to strict chemical laws and agencies, all the fearful effects of those distressing and often fatal complaints.

There is a case directly in point which came under our own observation, and which will forcibly illustrate both the effects and phenomena of the disease we have been describing, and the appropriate chemical remedies for that disease.

Some seven or eight years ago, a young man, a printer by profession, while boarding in our family, was attacked one night most violently with a complaint almost akin to the Asiatic cholera. Being reluctant to trouble the family, he made no one acquainted with his situation during the night, and, rising early in the morning, we found him lying upon the stairs, where he had reclined, almost perfectly helpless and exhausted, in his passage to his chamber. Seeing him in this miserable condition, we roused him, and aided him to his bed. As soon as there was light enough to see his complexion, we discovered that the surface and extremities of his system had a cold, bluish appearance, almost like the collapsed or lethargic state of the cholera; he was racked with violent and almost spasmodic pains, and was evidently sinking very rapidly into the arms of death.

We dispatched a messenger immediately for a physician; but, feeling that medical aid might possibly come too late, we concluded to do what we could in the meantime to check the disease. Knowing that he had often complained of acidity of stomach, and

thinking that this must be the primary cause of the distressing complaint under which he was groaning, we determined to administer relief upon strictly *chemical* principles. We accordingly mixed a tumbler of very strong sal-soda, which he drank. We then took a large fold of coarse flannel, filled it full of fourth-proof brandy, and sprinkled it over thickly with ground black pepper. This we spread over his stomach and bowels, and then covered him with an extra quantity of bed-clothes. The result was surprising and almost magical. In less than twenty minutes an active reaction took place in the system. The cold, blue complexion left the surface; the countenance put on the natural hue of health; a moist perspiration started out; the racking pains left him entirely, and he recovered immediately without further medical assistance.

Now, in this case it is perfectly evident that the cause of the disease was acidity. The matter in the stomach was deeply minus, the current of electricity was therefore *inward*, instead of being *outward*, and the surface and extremities were consequently left cold; the blood, in thickened, stagnated streams, pressed upon the heart and internal arteries, and, while the extremities were almost rigid, the internal apparatus of vitality was parched with a burning, withering heat. To restore healthy action again, all that was necessary was simply to reverse this order of the electrical condition of the system. This was done by neutralizing the minus with a plus *internally*, or an acid with an alkali, so as to give the current of electricity an *outward*, instead of an *inward*, direction,

by making the contents of the stomach plus, which would, of course, leave its internal coatings minus, and by aiding that outward current by the external application of brandy and pepper. Thus was the effect removed by removing the cause of that effect.

There are other diseases that can be just as speedily cured by understanding fully the electrical condition of the human system, and then by making such an application of chemical remedies as to neutralize the cause.

Pulmonary complaints can be cured, in ninety-nine cases out of a hundred, where internal irritation or inflammation is the cause, by frequent and severe friction, provided it be attended with proper exercise and diet. And why? Because it is an invariable law that, if the outer surface is plus, the inner is minus; and if the outer is minus, the inner is plus.

Now, if the inner be plus or inflamed, what is to be done? Why simply produce a counter-irritation, and keep up that irritation sufficiently long to permit all ulcerous affections to heal, as they will, when the current of electricity is outward, as we shall illustrate more fully after having entered into an examination of the blood and its agencies. This examination we shall preface by an extract from Liebig's "Animal Chemistry."

"If we hold that increase of mass in the animal body, the development of its organs, and the supply of waste—that all this is dependent on the blood, that is, on ingredients of the blood, then only those substances can properly be called nutritious, or considered as food, which are capable of conversion into

blood. To determine, therefore, what substances are capable of affording nourishment, it is only necessary to ascertain the composition of the food, and to compare it with that of the ingredients of the blood.

“The substances require especial consideration as the chief ingredients of the blood; one of these separates immediately from the blood when withdrawn from the circulation. It is well known that in this case blood coagulates, and separates into a yellowish liquid, the *serum* of the blood, and a gelatinous mass, which adheres to a rod or stick in soft, elastic fibres, when coagulating blood is briskly stirred. This is the *fibrine* of the blood, which is identical in all its properties with muscular fibre, when the latter is purified from all foreign matters.

“The second principal ingredient of the blood is contained in the serum, and gives to this liquid all the properties of the white of *eggs*, with which it is identical. When heated, it coagulates into a white elastic mass, and the coagulating substance is called *albumen*.

“Fibrine and albumen, the chief ingredients of blood, contain, in all, seven chemical elements, among which nitrogen, phosphorus, and sulphur are found. They contain also the earth of bones. The serum retains in solution sea salt and other salts of potash and soda, in which the acids are carbonic, phosphoric, and sulphuric acids. The globules of the blood contain fibrine and albumen, along with a red coloring matter, in which iron is a constant element. Besides these, the blood contains certain fatty bodies in small

quantity, which differ from ordinary fats in several of their properties.

“Chemical analysis has led to the remarkable result that fibrine and albumen contain the same organic elements united in the same proportion, so that two analyses, the one of fibrine and the other of albumen, do not differ more than two analyses of fibrine or two of albumen respectively do, in the composition of one hundred parts.

“In these two ingredients of blood, the particles are arranged in a different order, as is shown by the difference of their external properties; but in chemical composition, in the ultimate proportion of the organic elements, they are identical.

“This conclusion has lately been beautifully confirmed by a distinguished physiologist (Denis), who has succeeded in converting fibrine into albumen, that is, in giving it the solubility and coagulability by heat which characterize the white of egg.

“Fibrine and albumen, besides having the same composition, agree also in this, that both dissolve in concentrated muriatic acid, yielding a solution of an intense purple color. This solution, whether made with fibrine or albumen, has the very same reactions with all substances yet tried.

“Both the albumen and fibrine, in the process of nutrition, are capable of being converted into muscular fibre, and muscular fibre is capable of being converted into blood. These facts have long been established by physiologists, and chemistry has merely proved that these metamorphoses can be accomplished under the influence of a certain force, without the aid of a

third substance, or of its elements, and without the addition of any foreign element, or the separation of any element previously present in these substances.

“If we now compare the composition of all organized parts with that of fibrine and albumen, the following relations present themselves :

“All parts of the animal body which have a decided shape, which form parts of organs, contain nitrogen. No part of an organ which possesses motion and life is destitute of nitrogen ; all of them contain likewise carbon and the elements of water — the latter, however, in no case in the proportion to form water.

“The chief ingredients of the blood contain nearly seventeen per cent. of nitrogen, and no part of an organ contains less than seventeen per cent. of nitrogen.

“The most convincing experiments and observations have proved that the animal body is absolutely incapable of producing an elementary body, such as carbon or nitrogen, out of substances which do not contain it ; and it obviously follows that all kinds of food fit for the production either of blood, or of cellular tissue, membranes, skin, hair, muscular fibre, etc., must contain a certain amount of nitrogen, because that element is essential to the composition of the above-named organs ; because the organs cannot create it from the other elements presented to them ; and finally, because no nitrogen is absorbed from the atmosphere in the vital process.

“The substance of the brain and nerves contains a large quantity of albumen, and, in addition to this, two peculiar fatty acids, distinguished from other fats by containing phosphorus (phosphoric acid). One of these contains nitrogen (Fremy).

“Finally, water and common fat are those ingredients of the body which are destitute of hydrogen. Both are amorphous or unorganized, and only so far take part in the vital process as that their presence is required for the due performance of the vital functions. The inorganic constituents of the body are iron, lime, magnesia, common salt, and the alkalies.”

The above extract from Leibig, though a partial digression, has, nevertheless, been introduced because it contained two important facts—first, that the increase of growth and weight in the human system depends mainly or wholly upon the blood; and secondly, that the blood contains all those inorganic constituents of which the organic is composed. The blood, then, it seems, is the chief agent in the distribution to different parts of the system of the nutriment, which either builds or repairs the organic structure, and supplies what is wasted. All the chemical changes, then, which transform the vegetable and animal nutriment into chyle, the chyle into blood, and the blood into flesh and bones and nerves and muscles—the gastric juice, the saliva, the tears, and every other secretion, are performed through the medium and influence of the heart, veins, and arteries.

A very interesting question here suggests itself naturally to the mind, respecting the particular cause and the *modus operandi* of these multiform agencies, whose solution we confess is very difficult, but which can be somewhat elucidated by certain familiar facts of ordinary occurrence, from which certain common-sense conclusions can be logically drawn. How does the blood resolve the constituents of food into flesh,

or distribute its healthful and nutritious qualities into the organic mass of the system, and expel from that system those portions which are deleterious to animal life and vigor?

These questions can better be answered after examining the phenomena of respiration. The blood, when simply considered in regard to its ponderable elements, has no inherent power whatever to produce chemical changes, and to convert food into the component materials of the system, and separate that which is baleful and unhealthy from that which is not. That agency, so powerful and wondrous, belongs to the imponderable principle of the oxygen gas which is inhaled by respiration, and to that *alone*, and that, as we have heretofore abundantly proven, is positive electricity. The all-pervading electric agent, after all, does the work. And what are the phenomena attending some of its operations?

The lungs, as we have seen, are the grand laboratory where almost the whole chemical changes of the human system are affected. In them the venous blood is transformed to the arterial, for the venous blood is one substance, and the arterial quite another—that is, the one possesses some ingredients which the other does not, or else the one possesses some ingredients in greater proportion than the other. The venous blood in its passage through the veins, along the courses of the lymphatics, and by the absorbents and secretory organs of the system, brings along a load of carbon and other matters deposited by the food in different parts which are at war with life, and which, if not expelled from it, would bring this

wondrous but frail tenement down into the unorganized mass of mere lifeless material out of which it was constructed. The venous blood, we say, brings along this load in its passage through the lungs, and there exposes it to the action of the oxygen of the atmosphere, by which it is all decomposed when the breathing apparatus performs its appropriate duties; the carbon is expelled in the form of carbonic acid gas, a most deleterious poison, and other pernicious materials find vent in the same way. The blood being purified from those substances which will not aid in the construction, stability, and healthfulness of the organic system, and changed or arterialized from a dark purple to a florid red color, bounds on its gladsome course with greater elasticity, making the spirits buoyant, and spreading the flush of health over the cheeks.

From these facts, which are incontrovertible, and can be tested, it will be very readily perceived, what must be the fatal or pernicious consequence of any defect in the chest, either natural or acquired, by those sedentary or slothful habits by which the breathing apparatus is circumscribed or compressed, so that the air-cells cannot be expanded and completely filled at every inhalation by the vivifying and purifying oxygen. By such defect, it is evident that but a small proportion of oxygen would be brought in contact with the blood. Of course, but a small quantity of those deleterious substances, about which we have remarked, would be decomposed and expelled by it. Being retained in the system, they would aid to pull down rather than build up, to enfeeble

rather than strengthen, the body; the lungs would become tuberculous and ulcerated, the liver inflamed, the heart and whole arterial system diseased, and the citadel of life would be prematurely and inevitably stormed and sacked by the invading forces.

How very essential is the knowledge of this fact to parents, guardians, and teachers in the physical education of children committed to their care and culture! If they would give them a healthy constitution, they must pay particular attention to the development of this curious apparatus of animal life—the grand laboratory in which are wrought the chemical changes, the decompositions and the recompositions, that build up and beautify, or pull down and deform the organic structure; for, to use an appropriate figure, the lungs are the furnace, the blood is the liquid of life, and oxygen is the fuel that heats it up, and makes that steam-engine, the heart,* propel the streams of vitality through all their purple channels. If the furnace be compressed from any cause—if it be cramped and small, the quantity of fuel consumed will, of course, be proportionably less, feebler will be the strokes of that engine, and more dull, languid, and stagnated will be the current of life.

It is plain, then, that the system of hot-house culture, which prevails to too great an extent at the present day, is *all wrong*. Children should not be brought up in the shade. They should be permitted and encouraged to engage in those animating sports in the open air which quicken the respiration, and inflate and dis-

* Not the heart, but electricity or oxygen gives the life power that acts on the blood.

tend, to their utmost capacity, every air-cell of the lungs. Yes, they should inhale with delight the brisk breezes, and face the keen northwester, when Fahrenheit is five or ten degrees below zero. By such a course of physical education, it is perfectly evident that the foundation must be laid for a healthy constitution, by giving a round, full development to the lungs, in which the streams of life are purified and prepared for the healthful construction of the physical organization.

In this connection we will notice a few phenomena, the causes of which are not generally understood, and which will throw light upon the interesting subject we are discussing.

It is a fact well known to every observer, that children consume vastly more food, in proportion to their bulk, than adults; but the reason *why* they do is not so obvious. There is, however, a definite chemical cause. Children breathe much more rapidly than grown persons; they therefore inhale a much greater quantity of oxygen gas; this decomposes and prepares the food for organization into the living mass much faster; and for this reason alone, a healthy child eats sometimes as much or more than an adult of four or six times his bulk, and grows, therefore, proportionably faster. This, too, is the reason why a child cannot bear the gnawings of hunger, and wants to eat oftener, and therefore sometimes becomes a source of extreme annoyance to the careful and economical provider who does not understand the cause.

Owing to rapid breathing, "a bird, deprived of food, dies on the third day, while a serpent, with its slug-

gish respiration, can live without food three months, and longer," as has been proven by those enormous anacondas which have swallowed deers whole, and then lain torpid for whole months, while the food is undergoing the slow process of digestion.

The reason why a laboring man requires more food than one who does not labor at all, is this: His respiration is more rapid, and the volume of air is greater at each respiration. The amount of oxygen, therefore, being greater, a larger amount of food is of course burned or decomposed by that oxygen, and so a greater amount is necessary to supply the exhaustion. It is worthy of remark, also, that the pulsations of the blood are proportionably quickened by the inspired oxygen, which shows that it imparts caloric or electricity to the fluid in proportion as it is inhaled.

A thousand other facts upon this subject, respecting the reason why we require more food in the winter than in the summer—why the inhabitants of the polar regions eat more and heartier than those in the torrid—why a child requires more sleep than an adult, and a laboring man than an idle one—why sedentary persons are simultaneously afflicted with the loss of appetite and a disinclination to sleep—and why the blood of a person is just as warm in Nova Zembla as on the desert of Sahara—might be enumerated until this fruitful subject alone should extend out into a volume. Our limits, however, forbid an extension. Suffice it, therefore, to remark, that all these facts, and many others which might be enumerated, result from certain invariable chemical changes wrought by the electric agent.

As, in another part of this lecture, we have given the phenomena of a diseased body, when minus, and suggested the appropriate remedies, we will now, for a moment, take into consideration one charged plus, or a person afflicted with a raging fever. Some of the symptoms are a flushed countenance, turgid veins, a parched tongue, a headache owing to a rush of blood to that region, quickened and violent pulsation, rapid and labored breathing, and a hot, dry, husky surface. And now what are the chemical causes and the appropriate chemical remedies for such a state of the system? Owing to a cold or some other cause, the natural, healthful perspiration of the body, by which a proper electrical condition expels certain impurities, is checked and entirely stopped by the closing of the pores. The consequence is that those impurities enter in and derange the circulation, are carried by that circulation through the lungs, and there come in contact with the oxygen. These impurities are burned fiercely by that agent, the heat enters into the system — both the pulsation and the respiration are quickened; this increases the amount of oxygen until the blood is almost made to boil, and the difficulty is increased until the disease is either checked or else terminates in death.

Now, what are the appropriate remedies for this plus condition of the system? Why, evidently minus, cooling substances. The acids should be freely administered, and such alteratives as shall remove the cause, uncap the closed pores, make the impurities exude again in their accustomed channels, and thus prevent the oxygen from burning up the system by

its fierce ignition of those impurities in the lungs. Those internal remedies should evidently be always aided by such external applications as are calculated to accomplish the object, such as bathing, and friction with such volatile liquids as will evaporate rapidly and carry off the surplus caloric, which have the tendency to aid in producing perspiration.

In our closing lecture of this series we shall have occasion to make a few additional remarks upon this interesting subject; but feeling that it is impossible to do justice to it in a work so limited, we intend, so soon as we shall have sufficient leisure, to publish a volume devoted entirely to the subject of animal electricity and electric pathology.

LECTURE IX.

ELECTRO-MAGNETISM.

AMONG other important designs, it is our object, by the present course of lectures, to prove the identity of all the imponderables. One very essential link in the chain of evidence will be furnished by the investigation of Electro-Magnetism. Until recently it was supposed to be an agent entirely distinct and different from electricity. But it is now satisfactorily proven to be the same thing in essence.

This agent of nature was first discovered in a certain ore, found upon Mount Ida, in Asia Minor, by one Magnes, a shepherd, from whose name the word *magnetism* is derived. This ore is called, by mineralogists, *magnetic iron ore*, or in common parlance, the load-stone.

The singular and wonderful powers which it exhibited in holding with considerable tenacity the various metals first led to its development. It was also ascertained that it would not only exert an invisible and unaccountable influence over metals, but that it would impart to steel permanently the same kind of mysterious influence.

No wonder that this ore was regarded by some as a talismanic or a magic rock, in the earlier ages, when the idea prevailed to a considerable extent that

unearthly beings could throw their spells of enchantment around substances.

It was next discovered that if steel bars, which had been thus magnetized by the loadstone, were suspended at the centre by a thread or balanced upon a pivot, they would invariably arrange themselves north and south. This led to the invention, as is supposed, by Flavio da Melfi, a Neapolitan, in 1302, of that important instrument called the Mariner's Compass, which opened a new era in navigation. Mrs. Somerville, however, thinks different. She thus speaks in the following extract :

“The inventor of the mariner's compass, like most of the early benefactors of mankind, is unknown; it is even doubted which nation first made use of magnetic polarity to determine positions on the surface of the globe; but it is said that a rude form of the compass was invented in Upper Asia, and conveyed thence by the Tartars to China, where the Jesuit missionaries found traces of this instrument having been employed as a guide to land travellers in very remote antiquity. From that the compass spread over the east, and was imported into Europe by the Crusaders, and its construction improved by an artist of Amalfi, on the coast of Calabria. It seems that the Romans and Chinese only employed eight cardinal divisions, which the Germans successively bisected till there were thirty-two, and gave the points the names which they still bear.”

Before this auspicious event, the wary seaman cautiously coasted along the shore, and dared not venture far from land upon the ocean, where the

foaming waste of waters seemed to him an impassable barrier. But the compass changed the whole scene. With it the mariner fearlessly spread his canvass to the breezes, although assured that they would quickly hurry him away from the sight of his native shores and mountains. Guided by his faithful magnet, he left the coast, to which he had formerly clung so timidly, "*far, far behind him,*" and sometimes held his onward course for weeks, and even months, through the wide waste of waters, without a glimpse of land to tell him where he was, and yet so perfect was that guidance, that, at any given moment, he could tell the latitude and longitude of the spot he occupied.

One important effect of that invention was the discovery of the happy country where we now dwell; for, had it not been for the unerring guidance of the magnet, through calm and through storm, Columbus, notwithstanding his skill in navigation and the dauntless intrepidity of his character, could never have found his way across the ocean from Europe to Hispaniola.

The *cause* of magnetism was, for centuries after its discovery, enveloped in inscrutable mystery. But, by the recent experiments and investigations of philosophers, that mystery has been satisfactorily solved. About sixty years ago it was ascertained by the celebrated Beccaria, and by our sagacious countryman, Dr. Franklin, that steel and iron could be rendered magnetic by electricity. Since then, by the conclusive experiments of Professor Oersted, of Copenhagen, Professor Moll, of Utrecht, M. De la Rive, of Geneva,

M. Arago, of Paris, Dr. Wollaston, Sir Humphrey Davy, Mr. Faraday, Dr. Herschel, Mr. Christie, and many other philosophers of Europe, together with those of Professor Henry, Dr. Hare, Professor Silliman, and others of our own country, it has been demonstrated, beyond the shadow of a reasonable doubt, that all magnetism is produced by electricity.

Professor Oersted, in 1819, found that, by passing a current of galvanism around iron of a certain quality, by means of insulated copper wire, it was made strongly magnetic, and exhibited north and south polarity,—one extremity of the iron attracting the north point of the needle, and the other the south. It was also ascertained that by passing a galvanic current around steel in the same way, it could be made permanently magnetic, the same as if rubbed upon the loadstone.

In the language of Mrs. Somerville, “very delicate experiments have shown that all bodies are more or less susceptible of magnetism. Many of the gems give signs of it — cobalt, titanium, and nickel sometimes even possess the properties of attraction and repulsion; but the magnetic agency is most powerfully developed in iron, and in that particular ore of iron called the loadstone, which consists of the protoxide and the peroxide of iron, together with small portions of silica and alumina. A metal is often susceptible of magnetism if it only contains the 130,000th part of its weight of iron, a quantity too small to be detected by any mechanical test.

“The bodies in question are naturally magnetic, but that property may be imparted by a variety of

methods, as by friction with magnetic bodies, or juxtaposition to them, but none is more simple than percussion. A bar of hard steel, held in the direction of the dip, will become a magnet on receiving a few smart blows with a hammer on its upper extremity; and M. Hansteen has ascertained that every substance has magnetic poles when held in that position, whatever the materials may be of which it is composed."

It would be impossible, for the want of both time and room, to enter into a detail of the rise and progress of the science of magnetism, and trace the succession of various improvements made by the investigations of the learned. We must, therefore, content ourselves with a few brief remarks, in addition to what we have already said.

A variety of experiments have been made by many of the learned, at different intervals, "but the most astonishing ever exhibited to the world in the production of magnetism by galvanic currents, are those performed by Professor Henry and Dr. Ten Eyck, of Albany, in 1831. They constructed a horseshoe magnet of Swedish iron, weighing sixty-nine and a half pounds, with an armature weighing twenty-three pounds. Around this magnet they wound twenty-six strands of copper bell-wire, each thirty-one feet long, making eight hundred and six feet in the whole. About eighteen inches of the ends of the wire were left projecting, so that the aggregate length of the coils was seven hundred and twenty-eight feet. On connecting the wires with a battery of four and seven-ninths square feet, the magnet supported two thousand

and sixty-three pounds. In one experiment with a smaller battery, the armature continued to support more than one hundred and fifty pounds three days after the battery had been excited.

From experiments already made, there seems to be no limit to the extent to which this wonderful power can be increased by the increase of the size of the magnet, and the increase of the number of coils of wire.

How incomprehensible the force here exhibited — how disproportionate seems the cause to the effect! When the iron is bent, and wrought into its proper form, and wound with the requisite quantity of copper coils, it will not suspend a single ounce of itself. But just send a stream of electricity or galvanism around those coils, and, with its poles suspended downwards, it can be made to sustain four or five thousand pounds, without any visible chain of connection to hold the ponderous mass, and without having its own weight increased a single perceptible particle. This immense load is sustained there by no iron manacles, no hempen cord — hung there apparently upon nothing tangible, visible, or corporeal — sustained by the simple unaided ligaments of cohesive attraction. Who, after witnessing such an exhibition of incomprehensible force, — who can doubt, for a moment, but that the powers of all other agents in nature are weak and impotent when compared with this? Who can doubt, for a moment, but that, if its almost omnipotent energies could be harnessed appropriately to machinery, by any invention, they would operate that machinery with a force as resistless as that

exhibited by the bolt of heaven? Who can doubt but that its prodigious might is brought to bear upon the perfect machinery of the universe, and that it whirls the ponderous planets in their spheres and hurls the comet blazing through its lightning course?

Not only have magnets of great power been produced by electricity, but, quite recently, a surprising motive power has been developed upon a small scale. Miniature magnetic machines have been constructed, which would rotate upon their axis with a prodigious velocity, varying from five to fifteen hundred revolutions per minute, that being from three to five times as rapid as any revolutions produced by steam.

There have been invented two different kinds of electro-magnetic machines — the one operated by simple attraction, or by the influence of iron alternately magnetized and demagnetized by alternately breaking and closing the galvanic circuit, as it is called; and the other by attraction and repulsion, or a change of polarity, which is effected by such an arrangement that the galvanic current circulates half the time around the magnet in one direction and the other half in an opposite direction, whereby the poles of the magnet change alternately from south to north and from north to south, the polarity of the magnet being dependent upon the direction of the galvanic current around it.

Motion was produced, in 1830, by means of a galvanic magnet, constructed by Professor Henry, and so arranged that it caused a beam, suspended by its centre, to vibrate like the walking-beam of a steam-engine. Taking an idea from this invention of Henry's,

similar machinery was constructed in Europe. Mr. McGauly, of Ireland, reported, in 1835, a galvanic machine to the British Association, and Mr. Sturgeon, of Woolwich, in England, gave a description, about the same time, of one which he used upon his premises for pumping water, and for other mechanical purposes. But *rotary* motion was first produced by Dr. Edmonson, of Baltimore. In 1833 or 1834, he constructed a very simple, but yet a very beautiful electro-magnetic machine, called *Edmonson's Rotating Armatures*, which was composed of a brass wheel, containing a small brass hub and an axle about four or five inches long, with six spokes of brass wire an eighth of an inch in diameter and six inches long, with soft iron armatures, composed of wire, a quarter of an inch in diameter and two inches long, screwed upon the ends of the spokes, and arranged parallel with the axle. Through two brass pillars on each side of the wheel, which was horizontal, passed two screws which formed pivots, upon which the wheel could revolve lightly and without much friction. At a little distance from one end of the axle was screwed a brass plate disc, about three inches in diameter, and at the same distance from the other end a serrated disc, containing as many points as there were spokes and armatures. These revolved in cups arranged underneath containing mercury. On the outside of the whole was placed a single electro-magnet of small size, which, when charged with a small battery, would attract the soft iron armatures successively toward itself, until they came to the point where it would hold the iron and prevent motion, were it not so

arranged that the movement of the wheel would demagnetize the magnet, by lifting the point of the serrated disc out of the cup of mercury, and thus by breaking the circuit explode the magnetism in a brilliant galvanic spark and let the armature pass by. This wheel could be made to revolve from three to five hundred revolutions per minute.

Although it has been generally supposed that Davenport first produced rotary motion, by means of magnetism, yet this honor, as we have shown, belongs to another, who invented his rotating armatures about three years before Mr. Davenport perfected his electro-magnetic machines.

These rotating armatures of Edmonson are moved by simple attraction. But to Davenport belongs, however, the exclusive honor of inventing a machine moved by alternate attraction and repulsion, which, for a time, astonished the whole scientific world, and inspired the general belief that the power of electro-magnetism was about to be brought to bear upon machinery.

A brief detail of the several stages of progression by which Davenport perfected his invention, and discovered truths which had, for ages, eluded the keensightedness of the scientific, would doubtless be interesting to those who are unacquainted with the facts.

Mr. Thomas Davenport was an unlettered blacksmith, of Brandon, Rutland county, Vermont. In the course of his trade he went, in 1833, to the Penfield iron works, at Crown Point, on Lake Champlain, to purchase iron. His curiosity was there very much excited by the operation of a revolving machine with

several hundred magnetized steel points or teeth, which passed through pulverized ore, to separate the particles of iron from the surrounding material. Finding, upon inquiry, that these points were magnetized by a small electro-magnet, weighing about four pounds, he inquired the price of the apparatus, and, instead of purchasing iron as he contemplated, he expended his money for the magnet and took it home. Filled with that kind of enthusiasm which completely absorbs some minds, and which appears superlative folly and mental hallucination to those dull phlegmatics who always plod along in the beaten path of grandfathers and great-grandfathers, he commenced a series of experiments with his magnet, assuring his neighbors and friends that it was his firm belief that this power could be made to propel the largest boats. Although this announcement was received by them with general incredulity and ridicule, and although he had to encounter every discouragement on account of deficiency in his pecuniary resources and the continual dissuasion of his acquaintances, he pressed forward with a commendable and indomitable perseverance toward the accomplishment of his object.

It is proved by all history that a mind which is truly inventive, and capable of conceiving grand projects, has the dignity to rise above the influence of both sneers and dissuasions, and to accomplish such projects, if they be within the range of possibility. Such was the mind of Thomas Davenport. He was neither discouraged nor disappointed by the reception he experienced. "He thought and reasoned for himself; and, relinquishing his trade, he devoted his

undivided attention to the object in view. After trying hundreds of experiments, and devoting several months to an intensity of reflection which would have brought many others to a lunatic asylum, he finally, in July, 1834, accomplished the arduous task of bringing the invisible and mysterious power of magnetism into subjection — a power which, ‘steady as the needle to the pole,’ had been thought the most unyielding of all others; forming an arrangement by which this very polarity, this steadiness of purpose, is made to produce rotary motion.”

After encountering many hindrances, Davenport perfected, so far as it was possible to perfect, his miniature machines so that they would revolve with almost inconceivable velocity. They consisted, sometimes, of both stationary and revolving magnets, so arranged that, by their movements, the polarity of the magnets would instantaneously change at a certain point, and thus the machines would be alternately propelled by attraction and repulsion, resulting from a change of that polarity.

As it would, by mere language, without the apparatus, be impossible to give such a description of the machinery as to convey a clear idea of the precise manner of its arrangement (by which polarity is changed during revolution) to the minds of those who have never seen it operate, and, as it would be unnecessary to give such a description for the satisfaction of those who have seen it operate, we shall omit it altogether.

After having perfected his machines upon a small scale, so that they performed admirably, he proceeded

to construct one upon a larger scale, for the purpose of acquiring power, if possible. But in this experiment he was unsuccessful, and the persevering originator of a wonderful invention has passed into obscurity again, like a flashing meteor, and is now almost forgotten.

When he proceeded to enlarge his machinery, he met with an unexpected and insurmountable difficulty, in the impossibility of so nicely arranging it that the polarity would change perfectly at the proper point and time, and the one force give place completely to the other. There would, on the contrary, be, at that point, a contention between the two powers of attraction and repulsion, which contention would neutralize the powers of the two, and bring the machine to a stand.

While investigating, in 1838, this interesting subject, we were satisfied that machines operated by a change of polarity could never be anything but mere philosophical toys, interesting and wonderful, but entirely useless. It occurred to us, however, that the difficulty could be obviated by machines operated by simple attraction, provided that there could be an arrangement made by which the powers should be kept up without intermission. This we effected by bringing a series of magnets to bear upon the same wheel, in such a manner that, by means of non-conductors between the serrated discs, by which the galvanic circuit was broken, one circle of the series should be charged while another was demagnetized, and so the power continued without intermission. Having been quite successful in the first model constructed, we sent a

description of the same to the Patent Office at Washington in 1838, designing at the time to have taken out a patent and to have tested the invention upon a large scale, but other engagements have prevented the contemplated experiment.

As far as this mysterious and wonderful motive power has been applied, it can be regarded only as a most interesting philosophical toy. But the question here occurs — can it be applied to any practical purpose — can machinery, upon a large scale, where great resistance is to be overcome, be propelled by it? This remains to be proven. We are not prepared to say that it *cannot*, nor are we prepared to say that it *can*. Of one thing we have a practical demonstration, — it operates well upon a small scale, and exhibits considerable force. Whether it will upon a large scale depends upon the developments of futurity.

Rotary motion was produced by steam fifty years before it was applied to any practical or useful purpose. Its miniature machinery was then looked upon as an interesting philosophical plaything, as electro-magnetic machinery now is. It has been only about ten years since the motive power of magnetism on a small scale was developed, and it would be forming a conclusion with more dogmatic positiveness than we are willing to form one, to hazard the assertion that locomotives may not, within fifty, nay, within twenty years, be driven with lightning speed over our railroads by magnetism, and the electric boat, instead of the steam boat, be propelled across the Atlantic. There are a thousand improvements yet to be made which have not even been *dreamed* of by

the most acute philosophers. Some Davenport may even now be perfecting machinery which may, by its successful operation, astonish the world as much as the motive power of magnetism did when first developed. There is certainly no lack of energy in the agent. Its inherent force surpasses steam, or any other natural agent. There is a superabundance of power, as is demonstrated by the magnet of Professor Henry. Its correct application is all that is needed, and we are by no means prepared to say that such an application cannot be made. From what we have seen, we are rather inclined to believe that it can, and that it will, although the person who is hardy enough to persevere may encounter as many sneers as the immortal Robert Fulton did before he succeeded in applying steam power to navigation.

We will close this lecture by remarking that, as our object is to prove the identity of all the imponderables, and that they are electricity, magnetism aids materially to demonstrate this, from the fact that a galvanic current will make a magnet, and out of magnets can be drawn both electric sparks and electric shocks, as in the operation of the magneto-electric machine.

LECTURE X.

LIGHT.

HAVING examined the subject of common electricity, galvanism, magnetism, and other kindred subjects, and proved their identity, and demonstrated that this indivisible, imponderable principle is the wondrous agent by which *all chemical changes* are effected, we shall now endeavor, by a formidable array of facts, and by conclusions drawn legitimately from them, to prove that the sun is the SOURCE of this agent. This will require us, in the first place, to investigate the properties of *solar light*.

This, it is evident, is to be regarded as the fountain from which continually flows all natural light, for, it will appear conclusively in the course of our observations, that it would be utterly impossible to produce fire were it not for the existence of this agent. And here an interesting question respecting its nature and essential properties forcibly suggests itself to the mind — What is that light? It seems to be a subtle, ethereal, all-pervading fluid. No sooner does it glance upon a substance than it is gone. Suddenly darken a room into which a strong flood of light is pouring, and it is all dissipated as instantaneously as thought. Not a solitary ray is left to illuminate the darkness. Blow out a candle, whose light can be seen by the

eye at any point for a mile in every direction around it, and which, therefore, completely fills several cubic miles of space, and not the minutest iota of time does that light continue after the candle is extinguished. A thunder-bolt blazes across the black canopy of a midnight of storm, and its scathing light fills perhaps a thousand cubic miles of space. Blinded by the intense and lurid glare, the eye of the beholder shuts for an instant, and opens — upon what? A darkness deeper, if possible, by contrast, than before. The lurid flash has gone — where? Is it annihilated? No. It is somewhere in a state of diffusion and consequent invisibility, and if collected under the same circumstances, it would exhibit the same flash as before, and again diffuse itself through the mass of surrounding substances. Light, then, as we have already remarked, is subtle, ethereal, and all-pervading.

It is imponderable too — that is, it can be neither weighed nor measured. When a ponderable substance of several tons bulk is completely saturated with it, the specific gravity of that substance is not increased the smallest perceptible particle.

Never, for an instant, is this subtle agent stationary. The lightning speed of its everlasting career can be compared with no other agent in nature except electricity. It glances quick as thought from heaven to earth — from the sun to the planets.

There are two theories respecting the substance or essentiality of light, both of which will, for a moment, be examined. Dr. Herschel and his coadjutors supposed that it was the effect of the undulation or vibration of a subtle, ethereal medium everywhere

present in nature, and that it is transmitted to the eye the same as sound is to the ear. Upon this hypothesis there would be no direct communication between the sun and the earth, or the other attendant planets, and this being the case, the generally received opinion among philosophers, that the movements of the planets are governed by a certain kind of influence exerted by the sun over them, would be erroneous; for we hold it to be a truth capable of the clearest and most logical demonstration, that there cannot be any influence exerted by one substance over another, without a direct and positive connection of some sort between those two substances. To suppose the contrary, would be to suppose that there is a connection and that there is not a connection in the same breath, which is a self-evident contradiction in terms. We hold such an influence, without such an actual connection, to be an impossibility in the nature of things, which, to speak reverentially, not even Omnipotence can overcome, for God himself never claims to do that which is an impossibility in the nature of things. But it may be said that the Almighty created the universe with a word, and that there is no positive connection between a mere word and such a stupendous effect. True; but if He created that universe with a word, his all-pervading Omnipotence was present to give that word efficiency; for to suppose the contrary, would be to suppose that God can withdraw himself from a positive connection with his own agencies, which is another self-evident contradiction, unless you can undeify the Deity and make infinity finite.

Besides, the opinions of Dr. Herschel upon this

subject are unphilosophical and contrary to known facts. Instead of undulating or vibrating, light moves in direct lines. This is capable of positive proof. The angle of incidence and that of reflection are the same. Let a stream of light fall upon a mirror at a particular angle, and it will be reflected from that mirror in an exactly opposite angle. It is a tested and acknowledged fact, also, that light will not pass through a bent tube. But if it moved in undulations or vibrations like sound, this would not be the case, for sound *will* pass through such a tube. These facts and arguments, therefore, prove that the hypothesis of Dr. Herschel respecting light is false and unphilosophical.

The other theory of which we spoke is that of Sir Isaac Newton. It was the opinion of that great philosopher, that solar light is an infinitesimal effluvia of matter, or an emanation of inconceivably minute particles flying off from the body of the sun, and darting in straight lines through that space which is occupied by those opaque bodies which are governed by its influences. This hypothesis we consider to be correct and philosophical, if we regard it as an emanation of matter, different in its nature and essential properties from ponderable, inert matter—if we regard it as an imponderable essence, as it doubtless is, governed by the very same laws, and exerting precisely the same agencies as the other imponderables, which we have already examined. Newton, however, left some things unexplained in his theory of solar emanation which, unless satisfactorily accounted for, would involve the subject in an inexplicable difficulty.

Although he maintained the opinion that light was constituted by a flight of particles from the sun, and thus far was doubtless correct, yet he neglected or failed to account for the supply of that waste of the substance of the sun which must unavoidably be the consequence. The objector to his theory who might wish to puzzle the philosopher, might put the question, "If light be an emanation of infinitesimal atoms or particles of matter from the orb of day, why is it not diminished—why not exhausted and blotted out?" And such a question too would be a very natural one, and deserving of attentive consideration. Light is constantly emanating from the sun. This is a known and a generally acknowledged fact in science. Every conceivable point of space for ninety-five millions of miles around that luminary to the orbit of our earth, and so around the whole circumference of that orbit, is constantly filled with this light; and as light is estimated to move from the sun to the earth in eight minutes, then this whole entire ocean of light, one hundred and eighty millions of miles in diameter and nearly five hundred and forty millions of miles in circumference, containing billions upon billions of cubic miles of light diffused over space, is displaced every eight minutes by a new emanation—a fresh ocean of light, and that by the flood-tides of another ocean, and that by another, and so on to infinity.

Nor is this all. The whole space between us and the far-off orb of Herschel is thus constantly filled with light, and that light is thus constantly displaced by wave succeeding wave in endless succession.

Now the idea that this is matter which is thus

passing off from the sun with the glance of the lightning-flash, and filling every eight minutes an almost inconceivable area of space, would be preposterous in the extreme, unless there were, by some process of nature, an adequate supply for such an immense and unavoidable waste. This conclusion is in strict accordance with every principle of philosophy, analogy, and fact. It is perfectly evident that particles flying off from a body must inevitably diminish that body. No matter how infinitesimally minute those particles, nor how immensely large the substance, this must be the case, so long as the smallest atom of matter conceivable possesses both length, breadth, and thickness.

It can, then, be mathematically demonstrated, as perfectly as any problem of Euclid ever was, that the sun, unsupplied from some source, would long since have been frittered away by infinitesimal abstractions, and been utterly annihilated by this waste, even though we should, for the sake of argument, adopt the supposition that a million of cubic acres of those particles, when condensed sufficiently, should weigh no more than the ten thousandth part of a single grain; for, however vast in magnitude be the substance, such a diminution as must take place by an emanation of particles so immense as to fill a cubic bulk of space one hundred and eighty millions of miles in diameter, and nearly five hundred and forty millions of miles in circumference, every eight minutes, must certainly annihilate that substance completely in process of time. As "a continual dropping wears away the solid rock," so a continual waste must eventually

exhaust— completely and utterly exhaust— even the bulkiest mass conceivable.

If light, then, be the emanation of infinitesimal effluvia from the sun, as it doubtless is, how shall we rescue the Newtonian theory from the difficulties in which it seems to be involved? We must suppose either that there is, somehow, an unseen and imperceptible return of those particles to the source from whence they emanated, or that that great fount of light is constantly fed by creative agency constantly exerted, or else, as the horrid alternative, that the world would long since have realized the terrific phantasies of Byron's poetic dream on darkness, when —

“The bright sun was extinguished, and the stars
Did wander darkling in the eternal space,
Rayless and pathless, and the icy earth
Swung blind and blackening in the moonless air.”

The latter alternative we know, however, has not taken place, and the proposition that the waste is supplied by direct creative agency, is contrary to all the analogies of divine economy. When the Almighty created the universe, he created also, it is presumed, all the natural laws and agencies by which that universe should be governed, until the present order of things shall be broken up by the same Omnipotent word and energy which established it, and

“Final ruin fiercely drive her ploughshare o'er creation.”

He did not leave his work half done. He completed creation — He pronounced the whole good, very

good, and on the seventh day He rested from his labor. It cannot be presumed that the process of creating new materials to supply any deficiency in this splendid machinery of worlds is now progressing. The supposition would be derogatory to the skill of the great Architect. It would be contrary to the analogy of all his doings. Although there are continual changes going forward in the materials of which this globe and its surrounding atmosphere is constructed — although there be a ceaseless progression of chemical decomposition and recomposition among various substances — although what was a tree one year may, by transformation, become glass the next — or what was grass one day may become either flesh or milk or cheese or butter the next — or what was fish in one age may be petrified into limestone the next, and, instead of floating in the water, become the material with which your parlors are plastered, yet it is presumed that not a single new particle has been added to the globe or its varied furniture since creation, however modified it may have been, either by nature or art. One might imagine, perhaps, that in the combustion of fuel there is some destruction of material. But such is not the fact. It has only undergone a change. Every particle of it exists some where, either in vapor or smoke or the gases, or in ashes. And so with everything else. When the streams dry up in the season of drought, there is not a drop the less water than before. It is either in the deep well-springs of the earth, or is borne about in the vapors of the atmosphere; nor is there a drop more when the streams are full, nor was there when

the windows of heaven were opened, and the fountains of the great deep were broken up, and the deluge covered fifteen fathoms deep the tops of the highest mountains. It was either spouted up from the subterraneous reservoirs of earth, or the surrounding atmosphere, which extends forty-five miles above the globe, gave out its watery treasures, or the melted icebergs came down in torrents from the Arctic and Antarctic seas.

From these analogies, and a thousand others unmentioned, we infer that no creation of material is progressing to supply the waste of the sun. Shall we then resort to the other hypothesis, that the otherwise unavoidable diminution of the sun is supplied by the return, through some channel, of those same particles, which have accomplished the object of their mission?

Let us see what testimony analogy furnishes upon this important subject, before we hazard an answer. The human body affords a good illustration. The heart sends out the vital stream by successive pulsations, through its purple channels, to the extremities of the system, and is in its turn supplied by that same blood which it sent out in its passage back through the little veins, to be again projected by the self moved action of the wondrous machine.

The waters of the globe afford another very good illustration. The ocean is, as it were, the heart of the earth. By evaporation it supplies the clouds with water, this is borne over the globe and discharged among the mountainous regions, to supply the high lakes and fountains. These send forth the little rills

and streams, which, uniting in their course, form rivers, which empty into the ocean again and keep that immense reservoir unexhausted. Now, what the heart is to the human body, or the ocean to the globe, I conceive the sun to be to the solar system. By its mighty pulsations, it sends out its living stream to vitalize and energize creation, and when one pulsation has done its work, and given its share of the mantling blush of health to the cheek of beauty, and of luxuriance to the verdure of vegetation, and of varied tints to the flower, and of ripeness to the mellow fruits, and of motion to the planets, it speeds on in its lightning circuit, and gives place to another pulsation, and thus pulsation after pulsation chase each other in one interminable and ceaseless round, supplying by some inexplicable method of return the waste which must otherwise accrue.

We have considered the Newtonian theory of the materiality of light as correct, though not matter, in the common acceptation of the term, for it is totally different from any tangible, appreciable form of matter with which we are acquainted — being imponderable and immeasurable, passing through transparent mediums without seeming to encounter any obstacle — entering readily into the eye, the tenderest and most delicate organ, without causing pain or being perceptible in its passage. The following appropriate extract from Ferguson's *Astronomy* will forcibly illustrate the extreme subtlety and imponderability of this agent:—"Light consists of exceeding small particles of matter issuing from a luminous body; as from a lighted candle such particles of matter con-

stantly flow in all directions. Dr. Niewentyt* computes that in one second of time there flows 418,660,000,000,000,000,000,000,000,000,000,000,000,000,000 particles of light out of a burning candle; which number contains at least 6,337,242,000,000 times the number of grains of sand in the whole earth, supposing 100 grains of sand to be equal in length to an inch, and consequently, every cubic inch of the earth to contain one million of such grains.

“These amazingly small particles, by striking upon our eyes, excite in our minds the idea of light; and, if they were as large as the smallest particles of matter discernible by our best microscopes, instead of being serviceable to us, they would soon deprive us of sight by the force arising from their immense velocity, which is above 164,000 miles every second,† or 1,230,000 times swifter than the motion of a cannon-bullet. And, therefore, if the particles of light were so large that a million of them were equal in bulk to an ordinary grain of sand, we durst no more open our eyes to the light than suffer sand to be shot point blank against them.”

Now, with respect to extreme subtlety, does not light resemble electricity? Is there any other agent in nature which will pass thus through the eye without affecting it except electricity, for that will thus pass? Let a pointed rod be connected with an electric machine, and a stream projected through the eye from that point will cause no more pain than light — though differently modified. And if light be elec-

* Religious Philosopher, Vol. III. p. 65.

† This will be demonstrated in the eleventh chapter.

tricity, there would then be an additional argument in favor of the supposition that emanations of this fluid return again to their source—the sun—as all electricity, however modified, moves in a circuit, and exhibits no effect except the circuit is closed.

This is doubtless a novel idea, and may, for that reason alone, be considered, at first thought, chimerical and baseless. But we only ask calm reflection upon the subject, and candid attention to it, for we are persuaded that, after mature consideration, it will not appear so visionary as may at first glance be supposed. If it perform a circuit, it must be so immense as to be almost beyond computation. To illustrate this subject, trace a single ray, for instance, in its passage from the sun out into space for millions upon millions of miles, and there would be a point in its outward passage, and its consequent continual divergence, that the ultimate particles which constituted that ray must of necessity begin to separate from each other. Now, when they come to that point of incipient separation, what becomes of them? If they make a complete circuit, as we believe they do, the ultimate particles which composed the ray would, when they began to separate, (if they have the same organic laws as electricity, which we shall prove,) present their negative or minus polarity toward the sun, and, in that separated state, they would be drawn back to their source by the simple laws of the attraction of opposite polarities, which we have already abundantly demonstrated.

But it may be affirmed that, as light moves in

straight lines, one part of our theory clashes with another, since, according to this view of the subject, it must move in *curved* lines. This apparent clashing, however, is very easily explained, and this objection readily obviated. So inconceivably immense is that orbit which is described by a ray, that, although it is *actually* circular, yet any perceptible part of the orbit which it describes would appear to be *straight* to us, and thus there be no clashing between the two positions in reality.

It would be very easy, we are aware, for a fruitful imagination to invent objections, but before our conclusions be confidently and positively denied, we would ask those who would invent such objections, to tell us what becomes of light if it does not thus move in a circuit, and thus return to its source. Is it annihilated, or does it become stagnated and dormant, and lose its inherent activity in the vast abyss of space? And if it move not thus, and return, we would ask those who invent such objections, if they are prepared, in any other plausible or rational way, to account for the otherwise unavoidable waste of the material of the sun? If they can, we will willingly become learners, and will pledge ourselves to give up all prepossessions in favor of any opinion which we may have harbored. But if they cannot, they are bound, we think, to consider well the propriety of making objections upon a subject when they know not positively whether their objections are well founded. Firmly believing, however, that they cannot, we shall, for the present at least, adhere to the conclusions to which we have already come.

Light then, doubtless, after having performed its office, returns to its fountain, and thus closes its circuit. Else, what, I ask, becomes of it? Has the earth, for instance, drank in and retained all the light which has been shed upon it by the sun since creation? If it had, we conceive it to be a proposition capable of the clearest demonstration that it would have been, by this time, a complete ball of light like the sun. Besides, had it retained all the rays which have fallen upon it since the morning of time, its bulk ere this would have been very sensibly increased; for, although light be imponderable, yet it is something, and is capable of accumulation, like other matter, if retained. Not only would the earth be increased by this accumulation, but every planet of the solar system, and the sun, as every one must see, would be proportionably diminished. And what would be the consequence of such a diminution of the one and increase of the others? Why, the perfect balance of the system, which produces such a wonderful regularity of revolution that eclipses can be foretold for years before their occurrence to the definiteness of a single moment, would be entirely destroyed, and the whole would rush headlong to the confusion and darkness of chaos. Neither the earth, therefore, nor the other bodies of the solar system, have retained the light which has fallen upon them, but having been as completely saturated the first twenty-four hours of their existence as ever, they have thrown off all superabundance, the same as substances do when surcharged with electricity.

We have dwelt upon this subject of the return of

particles to the sun with the more minuteness because, if true, it may account satisfactorily for an important phenomenon to which we shall have occasion to advert hereafter.

We shall defer until our next lecture the further consideration of this important and interesting subject, and hope, by still further argument and proof, to demonstrate the correctness of our position.

LECTURE XI.

LIGHT AND HEAT.

THE commencement of the present lecture will be the continuation of the subject of the identity of solar light and electricity. In the discussion of the subject, such a chain of proof will, we think, be linked together as to be conclusive and irresistibly convincing.

As the correctness of our theory depends mainly upon the demonstration of the proposition that light is electricity, we will proceed in the examination of proofs. The two possess many properties in common. Light, generally speaking, is attended with heat — so is electricity. Light has inconceivable rapidity of motion — so has electricity. The one is imponderable, immeasurable, all-pervading — equally so is the other. And what if they do vary in some of their appearances — vary in some of their effects and operations? Does that circumstance necessarily destroy their identity — their oneness in principle or in essence? Certainly not. Known and acknowledged electricities thus vary, and that, too, quite as widely. The spark and the shock of the electric machine are somewhat different from the galvanic current; the meteoric shower is different from the keen flash and fierce energy of the bursting thunderbolt; the blaze

of the thunderbolt is different from the mysterious corruscations of the Aurora Borealis and Aurora Australis, and these again are all different from magnetism or magneto-electricity. Even the very same galvanic current, when modified by machinery, as can be demonstrated with a piece of apparatus, is different under one set of circumstances from what it is under another. If a person take hold of the poles of a small battery, and close the circuit, he receives no shock. But pass that same current around a helix of copper wire, inclosing soft iron, and forming what is called the magneto-electric machine, and then, by the action of the machine, a person receives shocks whenever he closes the circuit, by taking hold of tin tubes having a connection by conducting wires with the positive and negative poles of the helix. This proves *conclusively* that dissimilarity in appearance or in action destroy not identity or oneness in principle or in essence. This dissimilarity depends on modification, and on that alone, the causes of which are sometimes apparent and sometimes latent. The want, then, of resemblance in any respect between light and electricity, destroys not necessarily their identity. And even on the score of similarity they are by no means materially deficient. There are, in fact, more points of marked resemblance between them than between many known and acknowledged electricities — more, for instance, than between the Aurora Borealis and magnetism. And were the attention of philosophers and chemists turned to the investigation of this subject with all that intensity which its importance demands, we are persuaded that more resemblances

still would be discovered. Who can tell but that if, by any means, an immense number of rays could be brought together into one line of light, as they are brought to a focus by the lens or burning-glass, and could they be continued onward in that line without being scattered—who can tell, we say, but that this condensation of rays might be one continual stream of fire, like that of the electric fluid?

But a truce to supposition. We need not resort to hypothesis or conjectures to establish the plausibility, or even the logical *certainly* of our argument. We appeal to facts—*incontrovertible* facts, to prove that light is electricity. These facts we shall glean from the observations of practical men, which are preferable to any philosophical surmises or fine-spun speculations.

Lieutenant Johnson, of the British navy, often noticed that a considerable variation of the needle of the compass was produced by the rays of the sun falling upon the glass which covers it.

In support of this testimony, I have that of Mr. Harris, a resident of Ravenna, Portage county, Ohio, who had been a surveyor at the West more than twenty years, and who had often been engaged in running lines. In the commencement of his business he was often much troubled by the variation of the needle, and imputed it at first to the vicinity of iron ore, which is the popular solution generally given for such phenomena. But he noticed, after a while, that those variations occurred in a cloudless day, and just about noon, when the sun was vertical. The idea occurred to him that it might be electricity, produced

upon the glass cover by the sun's rays. In order to test the correctness of that idea, when such variations occurred, he moistened the glass so as to dissipate the electricity, and found by so doing that the variation was instantly prevented. Since that he affirms that he has been no more troubled with the supposed attraction of metallic substances, and his remedy is an infallible preventive of the variations that so much troubled him.

Since we first commenced the particular investigation of this subject, in 1838, we have had frequent opportunities to consult the oldest and most observing practical surveyors, and they have, without an exception, in every instance corroborated the statements of Mr. Harris and Lieutenant Johnson. One whose name, for particular considerations, we shall omit, but who was as good authority, probably, as any one we have consulted, not only testified his firm belief in the cause assigned by Mr. Harris, but suggested the thought that both diurnal and annual variations of the needle might possibly be determined by the variations even of the thermometer.

But some may, perhaps, be willing to acknowledge the premises from which we started, but deny the validity of our conclusions. They may assent to the proposition that electricity causes such variations of the needle as we have been contemplating, and that electricity may be produced by the mere friction of the sun's rays upon the glass cover of the compass, but that it cannot be the sun-light itself. This, however, would be an assumption altogether unreasonable and unphilosophical. Even if produced by the friction

of the rays, (which cannot be the case, since light passes so readily through a transparent medium without friction,) either the light or the glass must give out the electricity; for in all cases where electricity is developed by friction, either the rubber or substance rubbed produces it. The one substance that affects the other is, uniformly, the substance that is the generating agent. Even if light, then, produces electricity by friction upon the cover, it, after all, develops it from its own substance, and so nothing is gained by the objector, nor are our conclusions at all impaired.

In addition to these facts, which are of themselves sufficient to demonstrate that light is electricity, it has been ascertained by the celebrated Mrs. Somerville, of England, that by passing the sun's rays through a prism, and separating them by analyzation into the seven primitive colors, the blue color possesses the power of imparting magnetism or polarity to the needle, and *magnetism* we now know to be electricity by experiments too conclusive to be controverted.

There is another very important fact respecting the organic laws of the constitution of both light and electricity, which furnish additional and weighty testimony in favor of identity. The attractions of electricity decrease in exact proportion as the squares of the distance increase, in receding from an electrified body. This is precisely, as we should suppose, the law of the divergence of light, and this law, which runs throughout all the imponderables, has its origin in the law of solar emanation or divergence, and the simple reason why the attraction of all bodies decrease

in proportion as the squares of the distance increase, is because the emanating influence of all bodies which constitute attraction obeys this law.

The very strongest testimony, however, in proof of our proposition is contained in the phenomena of the polarization of light, by which it is *demonstrated* that every particle of light, as well as of electricity, *has opposite polarities*. This curious subject will be more fully examined when we come to the discussion of the subject of caloric.

By a fair logical deduction, then, with facts ample to sustain it, we unhesitatingly infer that *light is electricity*.

Heat or caloric comes next in the order of remark, and, in the investigation of this subject, we shall accumulate such an additional array of facts as shall establish our proposition beyond the shadow of a doubt.

The same arguments which would prove that light is an electric fluid are applicable also to the agent of heat. Heat, like light, is imponderable, subtle, ethereal, and all-pervading. No obstacle can stay its *passage*. It insinuates itself between the particles of the densest bodies as though it were immaterial. Its power is prodigious — irresistible in its energies. It generates the tremendous power that propels the steamboat; and were it, or could it, by any means be confined in subterraneous volcanic caverns with bands strong enough, and there accumulated, it would, by the power of its expansive and explosive force, burst the solid globe to atoms, and send its shattered fragments in every direction through the vacuum that surrounds it.

With a glass bulb and tube, for instance, one of the energies of heat can be forcibly demonstrated. By inverting it, and inserting the open end in a basin of water in its natural state, you will perceive no effect whatever. But by passing into the tube the subtle agent of caloric from a spirit-lamp, and again inverting it, you will see the water rise with great rapidity, and fill more than nineteen-twentieths of the tube. This shows that heat has the power to expel the atmosphere and occupy its stead. But the moment you attempt to confine it there, by closing the tube, it is gone, like a flash — gone like a viewless, incorporeal, intangible thing, and the water rushes up to fill that vacuum.

If all the imponderables, as we have assumed, be identical, then light and heat are the same — they co-exist and are inseparable. But it may occur to some one that those phosphorescent substances which emit light do not also emit heat, and that our position is therefore untenable. This conclusion is, however, altogether too hastily formed. It will be seen, by the following lucid extract from Turner, that heat is *always* necessary to make substances phosphorescent.

“The chemical agency of artificial light is analogous to that from the sun. In general the former is too feeble for producing any visible effect; but light of considerable intensity, such as that from ignited lime, darkens chloride of silver, and seems capable of exerting the same chemical agencies as solar light, though in a degree proportionate to its inferior brilliancy.

“Light is emitted by some substances, either at

common temperatures or at a degree of heat disproportioned to the effect, giving rise to an appearance which is called phosphorescence. This is exemplified by a composition termed Canton's phosphorus, made by mixing three parts of calcined oyster-shells with one of the flowers of sulphur, and exposing the mixture for an hour to a strong heat in a covered crucible. The same property is possessed by chloride of calcium (Homberg's phosphorus), anhydrous nitrate of lime (Baldwin's phosphorus), some carbonates and sulphates of baryta, strontia, and lime, the diamond, some varieties of fluor-spar called chlorophane, apatite, boracic acid, borax, sulphate of potassa, sea-salt, and by many other substances. Scarcely any of these phosphori act unless they have been previously exposed to light; for some, diffused day-light or even lamp-light will suffice; while others require the direct solar light, or the light of an electric discharge. Exposure for a few seconds to sunshine enables Canton's phosphorus to emit light visible in a dark room for several hours afterwards. Warmth increases the intensity of light, or will renew it after it has ceased; but it diminishes the duration. When the phosphorescence has ceased it may be restored, and in general for any number of times, by renewed exposure to sunshine; and the same effect may be produced by passing electric discharges through the phosphorus. Some phosphori, as apatite and chlorophane, do not shine until they are gently heated; and yet, if exposed to a red heat, they lose the property so entirely that exposure to solar light does not restore it. Mr. Pearsall has remarked that in these minerals the phosphorescence

destroyed by heat is restored by electric discharges; that specimens of fluor-spar, not naturally phosphorescent, may be rendered so by electricity; and that this agent exalts the energy of natural phosphori in a very remarkable degree. The theory of these phenomena, like that of light itself, is very obscure. They have been attributed to direct absorption of light and its subsequent evolution; but the fact that the color of the light emitted is more dependent on the nature of the phosphorescent body than on the color of the light to which it was exposed, seems inconsistent with this explanation. Chemical action is not connected with the phenomena; for the phosphori shine in vacuo, and in gases which do not act on them, and some even under water.

“Another kind of phosphorescence is observable in some bodies when strongly heated. A piece of lime, for example, heated to a degree which would only make other bodies red, emits a brilliant white light of such intensity that the eye cannot support its impression.

“A third species of phosphorescence is observed in the bodies of some animals, either in the dead or living state. Some marine animals, and particularly fish, possess it in a remarkable degree. It may be witnessed in the body of the herring, which begins to phosphoresce a day or two after death, and before any visible sign of putrefaction has set in. Sea-water is capable of dissolving the luminous matter; and it is probably from this cause that the waters of the ocean sometimes appear luminous at night when agitated. This appearance is also ascribed to the presence of

certain animalcules, which, like the glow-worm of this country, or the fire-fly of the West Indies, are naturally phosphorescent."

Light and heat, then, we regard as the same thing. They coexist and are inseparable. All the perceptible difference between them consists in volume or degree, and in volume or degree *alone*, and not in nature. Light exists either *radiant* or in a state of *diffusion*, and, consequently, *latent*. It is *radiant* when coming from the sun to the earth, but the moment it strikes the earth it becomes latent, but it is still *light*, just as much, though not seen, as it was before, and, could it be condensed into the same compass, and under the same circumstances as before, it would become just as radiant as before.

Heat is only light in a state of diffusion, as we before remarked. This is proven by the fact that if you condense it sufficiently you make it light. Take a piece of iron, for instance, and heat it to a certain point, and it is still latent, or invisible; but condense a trifle more heat upon the iron, and it begins to be light — condense more still and it grows lighter; and so continue and you make it glow, at length, with a radiance almost as intense as that of the sun at noon-day, but still it is only heat. Light, then, is only heat *condensed*, and the more it is condensed, the more intense is that radiance; and, on the other hand, heat when latent or invisible, is light in a state of diffusion. All the difference, then, between the two is in volume or degree, and in volume or degree *alone*.

The same remarks apply with equal force to elec-

tricity. When condensed in the electric spark, or in the galvanic current, or in the blazing thunderbolt, it is *radiant* electricity, but when not condensed, it is *latent* electricity, or electricity in a state of diffusion and invisibility. But, whether radiant or latent, it is the same thing precisely, only accumulated in different volumes.

Some suppose that when the electric spark or the thunderbolt explodes, the electricity is destroyed. That, however, is an erroneous supposition, as can be proven by experiment. It only passes into a state of diffusion, and consequent invisibility, but is essentially the same thing as before, and, could it be collected again, would exhibit the same appearance as before, and explode in a flash equally intense.

Mr. Cross, a literary gentleman of England, passed several conductors for some distance over the trees in his park, and connected them all with a single one, which passed down through his parlor. In this main conductor, which passed through his parlor, he had a joint so constructed that he could break the connection, and leave a short interval between the two sections. Whenever he made the separation, whether in fair weather or in foul, there was a constant succession of brilliant electric sparks passing from one conductor to the other. Without this disconnection, the electricity would have passed over the conductor in just as great a volume, but would have been invisible or latent, and, of consequence, been the same precisely as if radiant.

The fact that luminous and invisible electricity are the same, though condensed more in one instance

than in the other, can be incontrovertibly proven by an experiment with what is called the spiral tube or diamond necklace. Over the glass, at very small intervals, are glued little pieces of tin-foil. There is probably a hundred of those pieces in a distance of two feet, and as many spaces between them. Now, communicate a spark of electricity, either from the electric machine or a charged Leyden jar, and in its passage through the tube it will become alternately luminous and latent one hundred times in the distance of two feet, which certainly would not be the case if electricity is destroyed or changed at all by explosion. It is latent when passing the tin-foil, and luminous when passing the intervals, simply because it is more diffused upon the tin-foil than in the spaces. Such an alternate arrangement of tin-foil and spaces might be extended until they should number many millions, and an electric spark would become alternately luminous and latent as many millions of times, in its passage over them. All the difference, then, between radiant and invisible electricity is in volume or condensation, and light and heat, as we have seen, exhibit precisely the same analogies.

We will here briefly enumerate a mass of additional facts which show the identity of caloric, light, and electricity.

Good conductors of heat are also good conductors of electricity; and poor conductors of the one are poor conductors of the other.

Heat affects bodies inversely according to the squares of the distance. This is the organic law of light, electricity, and magnetism. It speaks volumes

in favor of the proposition that the sun is the fountain of all electricity, since the basis of this principle, which runs through all the imponderables, seems to be laid in the law of the divergence or radiation of light.

Heat radiates in all directions like light, and its angle of incidence and of reflection are the same.

Vessels containing a hot liquid will radiate heat much faster, if they have a rough surface, than those which have a smooth and polished one. The reason of this is because the rough surface has a great number of minute *points*, from which the heat will escape, the same as electricity. The polished vessel has no *points* for radiation, and therefore retains the heat.

In accordance with the same law precisely, a polished vessel containing cold water when placed before a fire will not be heated so quickly as one having a rough surface, because it presents no *points* to attract heat, but reflects it rather.

A multitude of other facts could be collocated to prove conclusively that caloric and electricity are identical, but we must defer the remainder of our remarks to the next lecture, where we hope to demonstrate, among other things, that caloric is, in fact, the lightning of the clouds.

LECTURE XII.

HEAT—MAGNETIC ATTRACTION—THE AURORÆ.

SO important is the demonstration of the proposition that caloric is identical with the other imponderables, that we need offer no apology for its prolonged discussion.

That was an important era in the history of science when the lightning of the clouds was identified with electricity. Quite as important will be that era when *caloric* and lightning shall be demonstrated to be one and the same thing. If that ever takes place, the propositions we have assumed will be proven to be correct, beyond the possibility of cavil or the shadow of a doubt. This subject, then, is richly worthy of a thorough investigation. What are the phenomena attendant upon a thunderstorm, and what are the causes which conspire to produce it? Storms, attended with thunder and lightning, seldom occur, except in very warm weather; and the warmer the weather the more frequent they are, and the more vivid, rapid, and intense are the lurid flashes of the red bolt of heaven. They prevail in the northern zones in the summer, in the southern in the winter, and in the torrid regions throughout the year. This is the *modus operandi* of their doings :

During the hot weather of the summer months, a vast amount of caloric is poured down from the sun, and diffuses itself throughout the waters of the fountains, rivers, lakes, and oceans of the globe, and produces evaporation; for it is a fact which is generally acknowledged, and which no one will dispute, that caloric is the vaporizing agent the world over. This vapor, when generated, rises, we know, and forms the clouds. The caloric or heat which originated it is absolutely required to keep it in a state of vapor; for the moment it is abstracted by any process or cause whatever, that moment vapor ceases to be vapor, and is condensed into water again. This is proved by the condensation of vapor or steam, in a low-pressure engine for instance, where, by the abstraction of its caloric by cold, it returns to water.

Now, what takes place during a thunderstorm, after a hot sultry day, in which vast quantities of vapor were generated, and with which vast quantities of caloric rose to keep it in a state of vapor—what takes place, we ask, during a thunderstorm at such a time? Why simply this: Clouds that are charged with caloric, some plus and others minus, or some positive and others negative, are drawn together by the strong attraction of opposite polarities, two clouds, having an affinity for each other, rush together—the caloric which kept the vapor in a state of vapor is thus given out from one to the other—explosion takes place—the cause which produced the vapor, and kept it so, having vanished, it is condensed, of course, into water, and being then heavier than the surrounding medium—heavier than the circumambient atmos-

phere, which before sustained it, it is immediately precipitated to the earth by gravitation in the form of showers.

If a thunderstorm be watched, during the process of nimbification it will be seen that little dark clouds seem to congregate from every point of the compass, sometimes, and will conglomerate and thicken into deeper and deeper density and darkness—those which have the least caloric run the lowest, while those which have the greatest quantity run the highest; as they come parallel to each other, the lower strata will lift, while the upper will settle down, being attracted by each other, until they come within striking distance, when the plus of the upper strata is given out to the minus of the lower, in the form of an explosion, and during this concussion a large share of the caloric which was treasured up in the vaporous vesicles of both clouds is abstracted in thunderbolts, and thus copious discharges of condensed vapor or water follow each flash.

This accounts for the reason why the bolt most generally passes downward from the cloud to the earth. The upper strata being plus, gives out its caloric to the lower, which is always relatively minus, and therefore the scathing fires of heaven oftener leap downward than in any other direction.

Lightning, then, or the electricity of the clouds, is nothing more nor less than caloric, abstracted from vapor by strong chemical affinities, and by explosion. It is radiant caloric, and caloric is electricity. We believe that no philosopher or chemist can account for all the phenomena of the thunderstorm and of the lightning in any other way.

To show that we stand not alone in the advocacy of such sentiments, we will quote from that rare and excellent work by Dr. Metcalf, entitled *A New Theory of Terrestrial Magnetism* :

“It was observed long ago by Dr. Franklin that masses of vapor in different states of electricity attracted each other far beyond what he called the striking distance.

“It has probably been remarked by every person of observation, that light masses of vapor from the ocean, on approaching a mass of colder vapor from the northern points of the compass, approximate each other with accelerated velocity, when the colder current of vapor attracts caloric from the warmer, and it is condensed into a hazy mist or cloud.

“This is the rationale of aerial condensations. When a cloud is once formed, having parted with a portion of its caloric, *it is minus* in relation to all uncondensed or transparent vapor, which is plus, so that it becomes a centre of attraction, drawing to it successive masses of vapor, and abstracting their caloric, by which a perpetual condensation or nimbification is kept up, until an equilibrium is restored.

“It would seem obvious to the most superficial observer that caloric is the cause of evaporation, inasmuch as the greatest amount of evaporation takes place in regions which receive most of the sun’s heat. We may form some idea of the vast amount of caloric contained in atmospheric vapor, when we reflect that a pound of vapor will raise the temperature of a pound of water nearly 1000 degrees — that its bulk is increased about 1800 times in passing from a state of water to

that of vapor, and that all the rivers of the earth are supplied by its precipitation.

“What then becomes of all the caloric which must be given out during the condensation of this vapor? We know that thunder and lightning are most abundant in tropical regions, and during hot, sultry weather in the middle latitudes. Hence we infer *that the caloric of vapor, when greatly accumulated, is given out rapidly, in the form of electricity, on approaching a colder mass of vapor, which is negatively charged with caloric.*”

But it may, in this connection, be asked, what causes rain when lightning is not visible? The caloric is given out gradually and in such a volume that it is latent. This is either done by the vicinity of cold and warm masses of vapor, or the attraction of mountainous ridges, or of the minus earth.

If this be true, we can see at once the reason why, upon the great desert of Sahara, where there are no mountains, and where the earth is almost always plus, it rarely, if ever, rains. The earth being plus, and imparting caloric to the masses of vapor as they float over it, rarefies them, and makes them float *higher*, rather than aid in their condensation. It would be utterly impossible, therefore, for it to rain oftener upon that desert.

The same cause dissipates all appearances of rain in certain sections during the prevalence of a drought, so that showers will pass round, day after day, each side of them, and seem to shun them. The earth has in those sections become plus, and rarefies the clouds as they pass by, floats them higher, and

prevents condensation. As a general occurrence, such spots are encroached upon *gradually* by showers, until they are at length made minus, and then they are visited by the refreshing rain.

Could a large tower be erected, some one or two thousand feet high, in the very centre of the great desert of Sahara, and could its top be kept filled with *ice*, it would be the cause of the *perpetual* nimbification of clouds by its abstraction of their *caloric*. The consequence would be that it would be visited with frequent and vivifying showers.

The sun is the great fountain of light. Were it, however, extinguished, as in Byron's poetic dream on darkness, there would be neither heat nor electricity; and on the other hand, were there no heat nor electricity, there could be no light, for light is necessarily produced by the heat, which is indispensably requisite to render substances combustible, and without which they would not ignite, nor become combustible nor luminous at all. They are inseparable from each other and from electricity, and if you destroy the existence of the one, by the same process you destroy the existence of all.

The fact is the sun, which sends forth its streams of light and heat, is the great fountain of electricity—the great galvanic battery of the solar system. Could it be stripped at once of these splendors, which sweep incessantly over the vast domain of its dependent worlds, and be left a dark, cold, opaque body, what think you would be the consequence? Why, in less than twenty-four hours, yea, in less than twelve hours, this globe would become a solid mass of ice

from surface to centre, as well as every other body of the solar system. The very atmosphere would be congealed into an iceberg—the heart of nature would cease to beat—the pulse of nature would stand still—the powers of nature would all be palsied, chilled, and frozen to death. In such a supposed contingency, the orbs, if they moved at all, would wander—cheerless, black, and without order—through the vast expanse of desolation, dashing madly against each other in their blind and ungoverned career. Or else, as is most probable, in such a contingency, all motion would be stagnated, and every energy, every muscle, every nerve of the universe would be withered, stiffened, clothed with the rigidity of death. All sound would die away upon the palpable blackness of chaos. No elastic medium would convey the tones of harmony by its vibrations. All nature would be dumb.

While thinking upon this subject, I have permitted imagination, sometimes, to have unfettered sway, and to sketch the gloomy picture of the reality of such a supposition. In doing so, no description of the scene which I could paint seemed so graphic as the language of Byron's poetic dream on darkness, when

“———The world was void.

The populous and powerful was a lump—

Seasonless, herbless, treeless, manless, lifeless —

A lump of death, a chaos of hard clay.

The rivers, lakes, and oceans all stood still,

And nothing stirred within their silent depths.

Ships, sailorless, lay rotting on the sea,

And their masts fell down piecemeal —

As they dropped, they slept upon the abyss without a surge.

The waves were dead — the tides were in their graves —
 The moon, their mistress, had expired before ;
 The winds were withered in the stagnant air,
 And the clouds perished. Darkness had no need
 Of aid from them — SHE WAS THE UNIVERSE."

This description, or a description like this, though almost horrid enough to make the blood run chill, would be no fiction. Should the light and caloric of the sun be abstracted from the universe, there would be no electricity. It would, with the rapidity of a flash, complete its circuit, and perish with its cause. It could be no longer excited by friction. No galvanic arrangement of metallic plates could produce it. And then motion would cease — all life would instantly become extinct, and darkness and death would reign triumphant and universal.

In view of the facts and arguments which have already been submitted to the reader, we shall now consider it a conceded point that we have *proven* the *identity between solar light, caloric, and electricity*. To test still farther the correctness of the principles advocated, we will proceed to account, if possible, for certain mysterious and hitherto inscrutable phenomena, which can be satisfactorily accounted for if our positions be at all tenable.

There have for ages been certain vague and indefinite ideas floating in the public mind respecting the cause of magnetic attraction. While some have thought that there was a certain incomprehensible control over the needle of the compass exerted by the North pole star, others have approached somewhat nearer to scientific accuracy, by ascribing this controlling influence to terrestrial magnetism. But *how*

terrestrial magnetism is produced, and by what laws it is governed, the latter class have been about as much in the dark as the former. But if the positions we have assumed be true — if solar light and heat be electricity, and if the sun be its fountain — we have a key which will unlock all this mystery, which has hitherto been so inscrutable. To this important and useful purpose we will then apply it.

How, upon the theory that the sun is the fountain of electric influences, is terrestrial magnetism accounted for? The sun being the great galvanic reservoir, pours its streams of light and heat *vertically* upon the space embracing 47 degrees of the earth's middle regions, or $23\frac{1}{2}$ degrees each side of the equator, constituting the torrid zone. Let the temperature of the other zones vary as it may, the heat of the torrid is always uniform, and always excessive compared with either the temperate or the frigid zones. Thus the torrid regions, by being more directly under the influence of the sun's rays, become more deeply *electrified* than either the temperate or the frigid. What is the consequence? The equatorial regions are *positive* or *plus*, while the polar regions are comparatively *negative* or *minus*. There are two reasons for this. The 47 degrees, or the $3266\frac{1}{2}$ statute miles of the earth's surface, embraced between $23\frac{1}{2}$ degrees of north and $23\frac{1}{2}$ degrees of south latitude, constitute the bulkiest part of the globe, and even if the remaining part, including the north and south temperate, and north and south frigid zones, were as directly exposed to the sun's rays as is the torrid, (which supposition is, however, an impossibility,) the equator

would in that case still be plus and the poles minus, because the torrid regions are the bulkiest, and receive, therefore, the greatest amount of the electric fluid.

But the principle reason why the one is plus and the other minus is, because the one receives the rays of the sun more vertically than the other. Now for the application of an infallible rule. The equatorial regions being plus or positive, and the poles being minus or negative, there is a mutual attraction of the plus or superabundant fluid of the one and the minus of the other, upon that immutable and universal chemical principle that opposite polarities, or a positive and negative always attract, or that caloric always seeks to keep up an equilibrium, or to restore it when disturbed.

Besides, from this immutable and universal law of caloric, to keep up or restore an equilibrium, its particles, if they have opposite polarities, and if the plus end in radiations or emanations, always move first—must present, at the magnetic equator, their minus polarities to each other, and of course be continually repelled outward each way towards the poles.

So, then, there are actually two forces operating upon the superabundant electricity or caloric of the equator. And what is the consequence of the combined action of those two forces? Why, there will be two strong currents of electricity rushing continually, with lightning speed, from the equator each way, and these currents will, if this theory be true, run towards the point of greatest cold, north and south, instead of the geographic pole.

Some, perhaps, might contend that if the streams

of caloric constitute the directive power which is exerted by some agent over the needle of the compass, they must move spirally, in order to exert that influence which is actually exerted. Such may confidently infer this from the fact that certain experiments have been made, which would seem to prove it. A sheet-iron globe has been constructed, and so wound spirally, from the north to the south pole, with insulated copper wire, that it would make the needle arrange itself north and south, whenever the galvanic current was sent through the wire from one pole to the other, by connecting the wires at the two poles with the poles of the galvanic battery.

But the inference, that such must be the spiral course of the electric current around the earth, by no means follows from this experiment; for it must be recollected that there are two different currents, or two currents running in opposite directions from the equator to the poles, with their polarities arranged, of course, in opposite directions, the same precisely as if from the equator towards the poles of such a hollow sphere two currents should be sent in opposite directions from two galvanic batteries. By such an experiment, it could be demonstrated conclusively that the needle would arrange itself north and south, without having the galvanic fluid circulate around spirally.

But it would not discredit the correctness of our theory at all, if it were necessary that there should be spiral currents, for there is doubtless a *minor* current, running spirally around the earth, from west to east, owing to the fact that, by the diurnal revolution, that

side of the earth which is in darkness is relatively minus, when compared with that part which is under the immediate influence of the sunlight.

Now, then, for the explanation of magnetic attraction. It has been ascertained by experiment that currents of electricity will influence the needle. The reason, then, why the north pole guides the needle when north of the equator, and the south pole when south of the equator, is perfectly obvious. These currents of electricity, rushing from the equator to the poles, constitute what is called terrestrial magnetism. They give direction to the needle of the compass. As the point of greatest cold varies, so they vary, and as they vary so the needle varies.

Were the geographic pole of the earth the point of attraction, as has been supposed by some, the needle would *never* vary *at all*, but, as it is, it varies both diurnally and annually, because there are causes always operating at the North pole to change the point of greatest cold, particularly in the summer season, when the floating icebergs or ice islands of the Arctic are continually changing their position.

There are other mysterious phenomena, which can be rationally and philosophically accounted for *only* upon the supposition that there are such currents of electricity as we have been describing. They are the Aurora Borealis and Aurora Australis, or the northern and southern lights, for there are southern lights as well as northern. If caloric be electricity, as we have supposed, and there are currents passing from the torrid to the point of greatest cold in the frigid zone, the question arises, "what becomes of this electric

fluid when it arrives at that point of greatest cold?" Why, it streams up into the rarer regions of the atmosphere, and in its return to the equator, it spreads out into the lambent, waving light exhibited by the aurora, the appearance being the same precisely as electricity exhibits when passing through an exhausted tube, the same cause—the rarity of the atmosphere—operating in both cases to produce a luminous waving cloud, which proves that they must be identical.

As we progress in the investigation of this subject, we find evidence accumulating upon evidence—all linked together, and all sustaining the truth of our main proposition.

Captains Parry and Ross ascertained, in their expedition to discover a north-west passage, that the focal point from which streams upward the Aurora Borealis was exactly the point of magnetic attraction, for, when sailing over that point, the dipping-needle stood exactly perpendicular, while the horizontal needle would not traverse at all, but would remain in any position in which it was placed. When west of that point their dipping-needle would incline to the east; when east of it, it would incline to the west. They occasionally found that the focal point, or the point from which the Aurora Borealis streams upward, was south of them, and in that case the north pole of the needle turned round and pointed southward, so that, let them move wherever they might, its guiding influence on the compass was still the same.

They also ascertained another important fact—that this point of attraction was comparatively that of the greatest cold.

All these facts combining their evidence, and sustaining that of each other, can there be any rational doubt but that the caloric of the equator is electricity?

See how admirably these facts are linked together, and how each sustains the ultimate conclusion. Caloric streams down from the sun — deeply electrifies the equatorial regions — by a law of nature rushes towards the greatest cold of the poles — guides the needle invariably towards that greatest cold — streams upward, as it passes out from the magnetic pole — rises into the rarer or thinner regions of the atmosphere, and, like electricity in its passage through an exhausted tube, spreads out into a luminous cloud, and forms the Aurora Borealis at the north, and the Aurora Australis at the south. Now, can there be any stronger proof, or any greater accumulation of proof, that caloric is in fact electricity, short of actual mathematical demonstration? One who could not be convinced by such an array of facts, each supporting the other, could hardly be convinced, we should be inclined to suppose, by the evidence of his senses. He would be like that ancient sect of sceptical philosophers who doubted everything — even their own identity.

In our next lecture, we shall connect together several other important links in our chain of testimony in favor of the identity of all the imponderables.

LECTURE XIII.

GRAVITATION — COHESION — MOTION OF PLANETS.

IN continuation of our explanations of various mysterious phenomena of nature which have heretofore been left unexplained, or enveloped in a metaphysical fog, we would remark that there are yet other important and essential links in the chain of evidence, which we have been linking together, all of which will have a tendency to make the logical accuracy of our deductions more clear, and our conclusions more and more undeniable and convincing.

Gravitation, another imponderable principle of nature, is one of those links — a link too which, so far from diminishing or impairing in the slightest degree the strength of the previous chain of deduction, adds to it increasing power of tenacity, and resistance to efforts of prejudice or scepticism to break it — a link which is intimately connected, as we shall attempt to show, with the mysterious power of electromagnetism.

No topic, in the whole range of the sciences, has heretofore seemed to students more unaccountable — more involved in a dark and misty shroud of uncertainty, than gravitation. Upon what known philosophical, astronomical, or chemical law, bodies, within

a certain distance, are attracted *towards* the earth, has for a long time been regarded by the learned and treated as an inexplicable enigma.

It is no solution of the riddle—no satisfactory explanation, to affirm that it is *attraction*. If the attempt be made by any one so to define it, the question instantly suggests itself to the unsatisfied mind of the diligent inquirer after scientific truth—what *causes* this attraction—why do all bodies, when unsupported in mid-air, fall *to* the earth, instead of flying off in a tangent—*away* from it, into space? We answer, that there must be some *definite* reason existing in the nature of things for this phenomenon. What, then, is that reason?

It will not avail anything, as we have seen, to say that it is attraction, or that it is the attraction of gravitation. This method of solving the enigma would only be reasoning in a circle, as logicians would call it—would be only giving a simpleton's solution, by saying that a thing is so, *because* it is so. It conveys no definite idea to the mind—is referable to no general scientific law. So far as purposes of lucid and perspicuous illustration are concerned, it might just as well be said that attraction of *attraction* causes that known disposition of bodies to seek the earth, as to be said that the attraction of *gravitation* causes it, for the words indicating or defining the *cause* are, in both cases, equally vague, having no definite idea attached to either of them. If we are told that all bodies of any bulk and density have an inherent tendency to approach other bodies of matter larger and heavier than themselves, upon the principle of attraction, and

that this is the attraction of gravitation, is it any explanation at all? Certainly not. Instead of throwing any light upon the subject, it is only the substitution of one vague term for another term equally vague. The question still rushes upon the unsatisfied mind, with undiminished force—"What *causes* this gravitating tendency? Why do bodies tend downward towards the earth instead of upwards from it?"

Shall it be said that it is an insolvable mystery, which is beyond the ken of human investigation, and so let it pass? Will men permit themselves to be thus baffled in their researches into the nature and causes of things by difficulties which, perhaps, a stern and unbending perseverance might overcome? This would be neither wise nor manly. There is not, we are persuaded, the cause of a single solitary effect of any kind in the universe, except the great uncreated Cause of *all* effects—or, in other words, a single secondary cause of any effect whatever, which may not, in time, by patient and persevering investigation, by comparing laws and agencies and influences, be satisfactorily ascertained.

What, for instance, is a fundamental law of electrical attraction? Why, an excited body attracts an unexcited body that approaches it, in exact proportion to the squares of the distance. Iron, when temporarily magnetized by the galvanic or electric fluid, or steel, when permanently magnetized, attracts contiguous metals precisely in the *same proportions*; and although magnetism and electricity were once thought to have no sort of alliance with each other, yet they are now proven, beyond controversy, to be but one. And

what may we infer from this coincidence between the two, and the identity of their laws and agencies? Why, that any other imponderable which shall exhibit the operation of the *same governing laws*, without a *shade* of difference, may also, yea, and will be found to be produced by the very same *cause*, upon the immutable principle of nature, that like causes produce like effects.

Here then we have a key to unlock the mystery of gravitation — a rule to solve every enigma and every difficulty satisfactorily. The attraction which the earth exerts over loose bodies above its surface, is governed by the very same laws precisely as magnetism and electrical attraction — it draws them with a force which varies in inverse proportions according to the squares of the distance.

Gravitation, then, is nothing more nor less than terrestrial magnetism, produced, as all magnetism is produced, by electricity, and that electricity streaming down from the source of all electricity, the sun. Before this theory, every difficulty which surrounds the subject of gravitation vanishes at once. The phenomena of bodies gravitating towards the earth can be thus accounted for by the operation of known and acknowledged and tested scientific laws. The earth is, in fact, a magnet — exhibiting all the properties of a magnet — attracting the needle to the pole like a magnet — drawing bodies to itself with a force precisely conformable to the attractive force or influence of a magnet — is made a magnet by electricity — and that electricity is the light and caloric that streams from the sun. The attraction of gravitation, then, is the attraction of terrestrial magnetism.

It has been the current opinion, among the mass of the community, and even among scholars, that everything is attracted towards the centre of the earth, as though that possessed some mysterious, unaccountable power of attraction over substances, somewhat akin to the unphilosophical opinion, that the North pole star guides the needle of the compass, and that it increased all the way to that centre. But such is by no means the case. The attraction of gravitation, instead of being the greatest at the *centre*, is the greatest at the *surface* of the earth.

Were it possible, for instance, to perforate *through* the earth, exactly at the magnetic centre instead of the geographic, a substance which might weigh hundreds of tons at the surface would weigh just nothing at all at that centre. It would be suspended there, were the space large enough, without any apparent support, like a light needle, when suspended within a helix, or coil of insulated copper wire, while passing a current of galvanism around it. And why would this be the case? Because the electrical or magnetic attraction would be equal on all sides of the centre of the earth, and therefore a substance which would weigh several tons at the surface would there be perfectly balanced, without support, and would, in that position, weigh just nothing at all, since all weight depends upon attraction, and that weight is exactly proportional to the attraction. As the power of the attraction is equal on all sides of the centre of the earth, and as attraction *one* way, without a corresponding attraction the *other*, causes all weight, therefore a substance at this centre must weigh nothing, because

the attraction being in all directions equal, must be neutralized.

The attraction of gravitation, or, in other words, the attraction of terrestrial *magnetism*, which is the same thing precisely, is the greatest at the *surface* of the earth. It may be asked, then, — “Why do all falling bodies fall toward the centre?” Simply because the radiations of magnetism obey the same law precisely as the radiations of light. The lines of these radii, if continued on within the surface, or through the earth, from one side to the other, would intersect the centre, and the attractions of the surface are therefore directly *toward* the centre.

From the fact that the radiations of magnetism obey the law of the radiations of solar light, and all other light, — that is, from the fact that the divergence of the radiations of magnetism is, in the exact proportion of the squares of the distance, the same as the divergence of light, gravitation, therefore, attracts all bodies around it in proportion to the squares of the distance of those bodies. So that the organic laws of magnetism, light, and gravitation are the same, and like *laws* produce like effects as well as like *causes*.

Before dismissing the interesting subject of gravitation, we would express our belief that it is a proposition capable of demonstration that an increase of the material of the earth would increase its attraction, in precisely the ratio of the increase of the attraction of the magnet, by the increase of *its* material. Were the material of the earth *doubled*, for instance, its attraction would be *quadrupled*, precisely in accordance with the law of the divergence of light or the radi-

ations of electricity. Consequently the weight of all bodies upon its surface, of the same bulk and density, would, in such a supposed contingency, be quadrupled in accordance with an immutable law.

Now, from all that has been said, does it not appear perfectly evident that gravitation has a cause, as definite and as easily explained as magnetism, which cause is precisely the same. The great magnet of Professor Henry, for instance, to which we have already alluded, would, when fully charged with the galvanic current, *neutralize* all the power of the *earth's* gravitation, and make a body gravitate *upwards* from the earth with a power equal to *two or three tons*. And why? Simply because a vast volume of electricity was accumulated there in a small compass, by means of the insulated copper wires, around which the galvanic fluid circulated. Electricity or light, then, we can legitimately conclude, is the *cause* of gravitation.

The attraction of cohesion has the same cause as the attraction of gravitation. They are both, doubtless, produced by that electric cause, the light and caloric of the sun. The one is the attraction between *large masses*, and the other between the component *particles* of those masses; the one attracts at great distances, and the other at insensible distances—their attractions are, therefore, the same in essence, though not in volume or degree. What holds the armature of Henry's large magnet, when charged, but the simple power of cohesive attraction between the particles of the iron, which composes the material of the magnet and armature, which cohesive power is caused by

electricity? We believe it is nothing else. The same power, precisely, holds the particles of all bodies together, and that power of cohesive attraction varies often as the amount of *latent caloric* varies. Abstract the latent caloric of iron, for instance, by intense cold, or by any other cause, and you, in a proportionable degree, destroy its cohesive attraction, and make it brittle. This is proven by the ease with which iron is fractured in the intense cold of the winter.

By hammering iron when cold, or by rolling it in a rolling mill, it will also become brittle. And why? Because the caloric, which constitutes cohesive attraction, is pressed out upon the surface by closing the pores. This is proven by the fact that caloric accumulates upon the surface in proportion as the pores of the iron are contracted by the rolling-mill or the hammer, which drive out the latent caloric.

The various phenomena of capillary attraction can be referred to the same cause as cohesion—to the caloric, that electrifies all substances under its influence. The tallow that composes the candle, for instance, is drawn up into the wick during combustion by capillary attraction, and that attraction is caused by the caloric set free during ignition.

We are well aware that many objections to the validity of our positions can be started by fruitful imaginations, which may appear plausible and seem to conflict with the conclusions which we have drawn, but which must be deceptive, since the laws of nature do not clash, and, if some of the reasons and the modes of her operations are beyond the ken of the

acutest and most penetrating scrutiny, it amounts to no conclusive proof that we are incorrect. The question is simply this — have our deductions appeared rational, and in accordance with known and tested laws, and have they been amply sustained by an accumulation of appropriate facts? If so, we are under no obligation to explain mysteries in the *essential attributes* of an agent, while we are attempting to trace merely the *effects* of that agent, for most of those objections which are or may be started will be found, upon close scrutiny, to relate to *essence*, rather than to the *modus operandi* of that essence.

Such questions as these, for instance, may be asked by the cavilling objector. If caloric be the *cause* of cohesive attraction, why will its accumulation entirely *destroy* cohesive attraction, as in the instance of all melted metals? Or, if caloric be electricity, and, if electricity be magnetism, why does not its accumulation around the large galvanic magnet make that large magnet hot? Or, why will this agent under one set of circumstances produce an effect, and under another *destroy* that same effect it produces, if “like *causes* produce like *effects*?” These, and a thousand other questions, might be proposed by the objector, which are more easily asked than answered.

But, to show that they relate to *essence*, we will ask some questions equally puzzling about electricity, where there can be no mistake about the identity of the agent. Why will the very same current of galvanism produce *both* an *acid* and an *alkaline* taste? Why will electricity, under one set of circumstances, make a magnet, and why, under other circumstances,

will it *destroy* that same magnet? It will be readily perceived that it is much easier to “*ask* questions than to *answer* them,” and that such questions refer rather to an explanation of *essence* than of *effect*. That *essence* of electricity we never attempted, nor have we ever proposed, to explain. It is a wonderful agent, and as mysterious as it is wonderful. Its effects are varied by countless myriads of modifications, and these effects we investigate, rather than the inscrutable reasons why those modifications should be so multitudinous, and why they should, in some cases appear to clash.

To show that we stand not alone in the advocacy of the opinion that cohesive and capillary attraction are produced by caloric or electricity, we will quote from Metcalf’s “New Theory of Terrestrial Magnetism.” Speaking of caloric, he says:—“It seems to be a general law of this subtle element, that it repels its own particles, and is attracted, though unequally, by all other matter, with an increased ratio, as the squares of the distance diminish.*

“From which it follows, that when caloric is withdrawn from a body, that body has a stronger affinity for caloric than one which is filled with it; and two bodies charged with caloric, one plus and the other minus, will attract each other with a force proportioned to the different quantities of caloric which they contain, and to the rapidity of its conduction from one to the other.

* We do not believe in the above proposition, so far as reciprocal attraction is concerned. This would, as we have elsewhere shown, destroy the *vis inertiae* of ponderable matter.

“An experiment, which I inadvertently made when a child, strikingly illustrates this principle. On the morning of ‘cold Friday,’ as it was called through the Western country, I applied my tongue to a plate of cold iron, while the mercury was about fifteen degrees below zero, when it adhered with such force that the skin was removed on separating it. Captain Scoresby relates, that frequently such was the intensity of cold in the Arctic seas, that the hands of the sailors adhered fast to whatever metals they touched.

“In all such cases the temperature of the living body is from 115 to 140 degrees higher than that of the metals — in other words, the living body is charged plus, while they are minus; and the attraction continues until the equilibrium is restored, when it ceases.

“The same attraction takes place when the hand is applied to metals heated greatly above the temperature of the living body; and for the same reason, one of the two bodies being charged plus and the other minus.

“When the temperature of metals is greatly reduced, they become brittle, so that a slight blow will fracture them; the same effect is produced on iron by hammering, which presses out and expels from it that portion of caloric which is necessary to its cohesion and malleability. Hence it follows that a certain amount of caloric between the particles of matter is requisite to maintain their cohesion; but when the amount of caloric is increased beyond a certain extent, it separates the particles, and thus diminishes, or overcomes, the power of cohesion.

“A great variety of facts may be adduced to show that *capillary attraction* is owing to the operation of the same law. For example, if a piece of sugar be put into a glass of water, a portion of the caloric of fluidity leaves the water, enters among the particles of sugar, and diffuses itself equally throughout the whole. During this absorption of caloric by the sugar, the temperature of the resulting mixture is somewhat reduced, proving that, in relation to the water, the sugar is minus or negative, and the water is plus or positive.

“If the piece of sugar be cut into a cylindrical form, of one or two inches in diameter and five or six inches long, and one end of it only be inserted into a glass of water, the caloric of the positive fluid, being *strongly* attracted by the negative sugar, pervades it rapidly throughout, until the equilibrium is restored, when the entire mass is dissolved.

“M. Lehot found by experiment that under the same pressure, water rises higher in vertical capillary tubes as its temperature is elevated. (Bibl. Univers. Mars. 1820, p. 225.)

“The phenomena of a burning candle illustrates the agency of caloric in producing capillary attraction in a very striking manner. The wick is ignited, the tallow rendered fluid, and attracted by caloric so as to furnish a continual supply of combustible matter to the wick, which is decomposed and expanded into flame or light. The force and rapidity of capillary attraction, all other things being equal, are in proportion to the amount of heat given out in the wick.

“Capillary and cohesive attractions are only modi-

fied effects of the same cause. It is the attraction of caloric for the particles of water that holds them together—that gives its drops their globular form; as it is the attraction of caloric for porous solids and capillary tubes that raises the water above its ordinary level.”

If light and caloric be electricity, and the sun be the sole fountain from which it issues, as we have attempted in previous lectures to demonstrate, then its influence over the planets that revolve around it must also be an electric influence. If their motions are produced by the influence of the sun, then those *motions* must be governed by the laws which govern the electric agent.

We approach the discussion of this subject with the feeling that it is the most important, as well as the most interesting, of any contained in the whole series of lectures. If we shall demonstrate that the revolutions of all the planets, both diurnal and annual, can be philosophically accounted for, in accordance with those organic laws of electricity which have been, and may be ascertained definitely in the laboratory, in their action upon pith-balls or electrometers, then will our opinions upon this subject be triumphantly sustained beyond the influence of cavil, and their correctness incontrovertibly proven. But, if we shall not be able to demonstrate such an identity, then will it appear conclusive that we have been indulging in philosophical dreams or baseless chimeras of the brain.

What, then, are the forces which electricity exerts over pith-balls? They are two, which, as we have

heretofore abundantly shown, have their basis in the inherent organic laws of this agent, and depend always for their development upon a plus and minus.

And what are the two forces which have ever been supposed to govern the motions of the planets? Why they are what philosophers have denominated centrifugal and centripetal forces. The meaning of the one is, a tendency to fly from a centre; and that of the other, a disposition to seek the centre. Now these terms are, as any one must see, exactly equivalent to attraction and repulsion. Centrifugal is repulsion, and centripetal is attraction. So, then, we find that we have to bring to our aid no new forces, if we adopt the hypothesis that the influence of the sunlight upon the solar system is electric, since its two organic forces correspond exactly to the centrifugal and centripetal of all standard works.

How, then, is the diurnal motion of the earth, for instance, produced upon this hypothesis, taking the movements of this globe for example, since they are more familiar than those of any other planet? Why, simply in this manner. The sun illuminates one half of the surface of the globe, while the other half is in darkness. That hemisphere which is in darkness is relatively minus, when compared with that which is illuminated, and so, *vice versa*, that hemisphere which is under the direct influence of the radiance of the sun is relatively plus, while the other is minus. The plus of the one side will increase from morning until sundown, and the minus of the other from sundown until morning. This is in accordance with that tested fact that, if any substance be exposed to an

electrifying cause, it becomes plus, and the longer it is exposed to that cause, the more highly plus it becomes, and so, on the contrary, if any substance be removed from the electrifying influence, it becomes minus, and the longer it is removed, the more deeply minus it becomes. Now, what is the legitimate result of such a condition of the earth? That part of the earth which has been longest in the sun's rays has come, as we have said, to a highly plus or positive state—that is, it has come to that state in which, throughout the torrid regions and part of the temperate, there must be an outward emanation, which constitutes a plus or positive, since any substance exposed for any length of time to the electrifying cause must become positive.

By an immutable law of electricity, two positives repel. Therefore, that part of the earth which has been longest in the sun's rays having come to a positive condition, is repelled by the positive sun. But that part which has been the longest removed from the direct influence of the electrifying cause, and has, therefore, come to a deeply negative condition, would, of course, be attracted by the positive sun, since a positive and negative always attract. If this were the true principle of revolution of the earth upon its axis, the plus part of the earth must be always rolling *away* from the sun, while the minus part must be always moving *towards* it, from the fact that two positives always repel, and a positive and a negative always attract. And this *is* the case, not with the earth only, but with all the planets which compose the solar system. That part of all of them which has

been longest *in* the sun's rays, is always rolling away from him, while that part which has been the longest *out of* his rays, is always rolling towards him. In producing the rotary motion of the earth, then, upon its axis, it is evident that the sun exerts two forces upon it — the one of attraction and the other of repulsion — which would cause its diurnal revolution, since, if you strike a ball on each side with equal force, and in opposite directions, you give it the rolling motion.

The earth, then, revolves on its axis daily, by the influence of the two forces of attraction and repulsion exerted over it by the sun, and those are precisely analogous in every respect to those of electricity.

If this be not the precise influence which the sun exerts over the earth in the production of its diurnal motion, what is that influence? It is universally acknowledged that the sun governs all the motions of the earth. But, while such an acknowledgment has been made, there seems to have been no clear or well-defined idea in the minds of those who have made such an acknowledgment, as to what constitutes that ruling power. They have almost universally taken it for a conceded proposition, that such a ruling power of nature controls the movements of this globe of ours; but how it exerts such a control, they seem scarcely to have taken the trouble to inquire.

But if the sun governs the motions of the earth, it governs those motions in accordance with uniform, well-defined, and immutable laws. Now, if any one affirm that the sun controls the movements of the earth, he is bound to explain the principles of that government. If he cannot, how does he know that

there is any such government *at all*. He has no right to assert that one thing is governed by another without he can give some definite reason, or reasons, *why* he draws such a conclusion. Nor has he any right to object to conclusions which others have drawn from well-defined premises, and deductions founded in reason and sustained by well-attested facts.

We, for instance, have assumed the proposition to be true, and have endeavored to prove it, that electricity is the cause of all attraction and repulsion, upon both a large and small scale, and, consequently, of all motion among spheres as well as atoms, and that the sun is the fountain whence it originates. As part of a connected chain of antecedents and consequents, or of causes and effects, we have drawn the legitimate conclusion, from the practical results of this theory, that the sun governs the earth and the other planets of the solar system by an electric influence. That influence has been *tested* in the laboratory upon pith-balls, and is, therefore, acknowledged by all who pretend to any very extensive attainments in science.

Now we have shown that the diurnal motion of the earth can be produced by the streams of electrifying sun-light, *precisely* in accordance with those known and tested and universally acknowledged electric influences which are of every day occurrence, and are familiar to every schoolboy. And if objections be urged against such conclusions, those who urge them ought certainly to be prepared to explain the laws by which the sun governs the earth, more satisfactorily and plausibly, or else forever hold their peace, and acknowledge their incompetency to do it; for the old

stereotyped method of explanation, by referring the whole to the influence of the centrifugal and centripetal forces, without explaining *how* those two forces are produced, will not answer — will satisfy no inquiring mind.

Feeling the force of the deductions which we have drawn, and seeing the impossibility of denying our conclusions, if our premises be correct, some may be roused by the impulse of their alarmed prepossessions to attack some of those premises. They may deny that the earth becomes minus during the night, and therefore infer that there are no two forces of the kind we have mentioned. But such cannot have investigated the subject at all. The earth is a rapid radiator of caloric, and, therefore, when the cause of it is removed, it rapidly dissipates. The consequence is, that although the emanations of caloric are outward from the earth during the day, especially in the Torrid zone, they are inward from the atmosphere to the earth at night, as is proven by the deposits of dew, for these deposits result from the abstractions, by the minus earth, of the caloric of the vapor, which was generated in the day time, and rose from the earth by the force of emanating or plus caloric. The passage of caloric is, therefore, into the earth at night, from the surrounding atmosphere, and of course presents its minus polarities, as all inward currents do. This objection falls, therefore, to the ground for the want of the shadow of a support, and so would every other objection, we believe, because our explanation of the phenomena of the revolution of the earth is in accordance with the immutable laws of nature.

As we have already remarked, all the other primary planets obey the same laws precisely, or are governed by the same influences, in their rotary motions upon their axis, as the earth.

An objection may, however, be urged against this conclusion, from the fact that there is no uniformity in the diurnal revolution of those whose motions have been ascertained with certainty, since Venus turns on her axis in twenty-three hours and twenty minutes, the Earth in twenty-three hours and fifty-six minutes, Mars in twenty-four hours and thirty-nine minutes, Jupiter in nine hours and fifty-five minutes, and Saturn in ten hours and sixteen minutes.

Now, why is there so much dissimilarity in the revolution of these planets, if there be a common cause for it, and if the laws which govern that common cause are invariable? It must be owing to the different materials which compose them, to their different powers of radiating caloric, to their different distances from the sun, and also, doubtless, to their bulk. Venus is some twenty-eight millions of miles nearer to the sun than this earth, and its day is thirty-six minutes shorter than ours. Upon the supposition that the power or capability of each planet to radiate caloric decreases in exact proportion as the squares of the distance from the sun increase, about which we shall soon remark more at large, then the revolutions of each primary planet would be regulated in exact proportion to bulk and distance.

The difference between the relative distances from the sun of the Earth and Mars is forty-eight millions of miles, and the difference between the time of their

revolutions is forty-three minutes. Now, if we take those three planets—Venus, the Earth, and Mars—for data whereupon to make our calculations, we can determine with mathematical certainty whether any other causes than mere bulk and distance influence the rapidity of their revolutions.

The difference between the bulk of Venus and the Earth, in diameter, is two hundred and forty miles, between their distances from the sun is twenty-eight millions of miles, and between the time of their revolution, or the length of their day, is thirty-six minutes, while the difference between the bulk of the Earth and Mars, the next planet, is three thousand seven hundred and thirty-nine miles, between their distances is forty-eight millions of miles, and their time forty-three minutes. Into this account is to be taken the bulk and influences of the Moon, which the Earth carries along with it.

Without having space to enter into all the minutiae of a mathematical calculation in the present connection, it is our impression that, with these data before us, it can be perfectly demonstrated that the rapidity of diurnal revolution depends alone upon bulk and distance from the sun combined.

This accounts satisfactorily for the reason why Jupiter and Saturn revolve upon their axis in less than half the time of the revolution of our earth, although the one be three hundred and ninety-five millions of miles farther from the sun than the earth, and the other eight hundred and five millions farther; for Jupiter has a diameter about twelve times as great as our earth, making its bulk more than a thousand

times greater than this planet, besides carrying with it four large moons; and Saturn, exclusive of the weight of his enormous rings and *seven* moons, is nearly six hundred times larger than the earth. They may, therefore, in exact accordance with our data, both perform their diurnal revolutions in less than half the time of our earth.

Having come, by our deductions, to the conclusion that the rapidity of revolution depends upon the bulk of the planets, and their relative distances from the sun, we would here remark that, if the power or capability of the planets to radiate caloric decreases according to the squares of their distance from the great centre of the system, then there is a *definite* cause why they all occupy just the position they do. Were this the case, they could come no nearer to the sun than they now do, nor could they remove farther away from it, but must remain just in the position they do at present, and have done since creation, so long as their material remains the same, or they have the same power of retaining or radiating caloric.

For if they should come any nearer, it is evident that they must become plus, and so be driven back by the repulsion of two positives. And if they should recede farther from the centre, they would become minus, and so be drawn to the position whence they started by the attraction of a positive and negative. It is perfectly evident, then, that the planets are completely balanced in their orbits. They can neither fly away from them nor can they be drawn into the sun, for the agent that rules them, and governs all their motions, holds them just where they are with bonds

which cannot be broken, until the final "wreck of matter and the crash of worlds." Owing to this cause alone, the earth approaches the sun in one part of its orbit and is driven back in the other, the two forces keeping it balanced exactly in strict accordance with that law of caloric which has a tendency to keep up an equilibrium throughout nature.

Having accounted, rationally, for the revolutions of the planets upon their axes, upon the principles of electrical attraction and repulsion, how shall we account now for their annual revolutions around the sun? This, we confess, is a subject much more abstruse, and the problem is much more difficult to solve. But yet we believe that it is capable of being satisfactorily solved, in accordance with the very same electrical principles which we have already fully explained and tested.

But before we proceed to do this, it is necessary for us to state a few facts which will aid materially in the solution of this problem.

Not only do all the planets revolve one way upon their axis, but they all move in one direction around the sun. Their motions, also, decrease in regular proportions and gradations as they recede from the sun. Mercury, for instance, moves in her orbit one hundred and eleven thousand and ninety miles per hour; Venus eighty-one thousand; the Earth sixty-eight thousand; Mars fifty-six thousand; Jupiter twenty thousand; Saturn, according to Ferguson, eighteen thousand, and Herschel fifteen thousand.

It will be seen that their movements are regulated by distance from the sun, combined with bulk, and

we believe it to be a proposition capable of absolute demonstration that the decrease of the motion of all the planets in their several orbits would be in exact proportion to the squares of their distances from the sun, if they were all of the same bulk and density exactly, taking the present ratio of their movements as correct data from which to draw conclusions.

Now, then, for the explanation of the annual revolutions of the planets. The sun seems to turn on his axis once in twenty-five days. That may be nothing but a seeming revolution, owing to the movement of its emanations in vast orbits, as we have before remarked, and which would convey that impression to an observer upon this globe; but it may be real. Be that as it may, all the planets move the same way that the sun seems to revolve, and therefore the same way that its emanations move in their orbits.

Now by the influence of the rays of the sun, moving with lightning speed in their orbital course, must the planets be all moved in one direction, since all their movements, both diurnal and annual, are governed entirely by the emanations of the sun, as we have seen. This is, doubtless, effected by the amazing influence which, as we have upon a small scale demonstrated, opposite polarities have upon each other, in inducing the particles of the electric stream to follow each other, and to move with them either atoms or masses of ponderable matter.

"But why," it may be asked, "does not this tendency of electricity to control both atoms and masses of ponderable matter drag them outward, exactly in the line of the course of its orbital movements?"

Because, as we have seen, if they were moved outward from their present position, they must become immediately minus, and be drawn back by the positive sun. Besides, were not this the case, the inward passage of the electric rays, in their return, as we have before explained, to their source, the sun, being with a lightning speed, as rapid as their outward emanation, may have a tendency somehow to neutralize the tangential force, and at the same time aid in the propulsion of the planets in their orbits, as the propelling force, if they have any, would be in the right direction.

The eccentric movements of the comets are produced by the operation of the same laws as the movements of the planets. In the most distant part of their orbit, — a thousand millions of miles, perhaps, from the sun, or even more, — these wandering stars move very slow, and in the arc of a circle almost immeasurable, having lost their charge of caloric, and become minus. The sun, being positive, and they deeply negative, it begins to exert an attracting influence over them. As that attraction increases continually in proportion as the squares of the distance decrease, they move swifter and swifter, until, as they approach the sun, they sometimes fly more than eight hundred thousand miles in an hour. At their perihelion they are very near the sun, and become highly positive, as they revolve half round in its intense blaze, and are propelled back again into the fields of space with the same lightning speed that they were attracted towards the great fount of all motion.

In view of what has been said in the preceding series of lectures, how wonderful is the subject of

electricity — how various and how magical are its agencies ! It streams down in the vivifying rays of the sun — quickens and invigorates the sluggish pulsations of nature — preserves the warmth of vitality — works all the countless myriads of chemical changes — clothes the cheek with the blush of health — spreads a rich carpet of green over the landscape — dresses the forest in its foliage, and has, no doubt, a direct agency in the production and continuance of all the forms of both animal and vegetable life.

But there is a reverse to this picture. Not always does it, in the exhibition of its wondrous phenomena, put on an aspect of such blandness and genial benevolence, wreathing itself in sunny smiles. No ! Its countenance sometimes gathers either mysterious grandeur or terrific fearfulness ; sometimes it streams upward from the poles in splendid coruscations, and weaves a bright coronal of lambent light at the zenith ; sometimes it exhibits itself in the effulgence and evanescence of the meteor's flash and the meteoric shower ; sometimes it leaps out from the dark foldings of the storm-cloud, darts downward through the gleaming tempest, and, with a fearful energy, which none else but God can wield, blasts everything it touches ; sometimes it flames athwart the heavens, in the trail of the comet, as it speeds its erratic and lightning course, and makes the nations pale with forebodings ; sometimes it assumes the port and majesty and terror of the burning whirlwind — rushes forth upon the red wing of the Syroc, and sweeps with desolation the hot plains of Sahara ; sometimes it musters its almost omnipotent force in the deep

caverns of the earth's centre, and makes the globe tremble and reel beneath the tramp of the earthquake, and melts rocks, and pours rivers of lava from the crater's mouth, and hurls enormous masses of blazing matter above the clouds, and upheaves mountains from the depths of the ocean and piles them in the sky. Such are some of the wonderful agencies of electricity.



PART II.

ELECTRICITY AS A CURATIVE AGENT.

INTRODUCTORY.

THE first part of this volume, by Professor Brewster, with only a few exceptions or alterations, embracing the great and important subject of *Electricity* as a science, and a wonderful as well as powerful principle in nature, brings to our notice many new and interesting truths hitherto undeveloped and almost unknown—speaking of electricity only as a science or a power for man to use in the acquirement of wealth.

But the direct and more important principle of my discoveries and investigations are found in the use of these very electrical currents to heal the maladies of the mind and body of my fellow-beings, and that, too, in many instances when all other remedies have proved unavailing or ineffectual. This first principle, *electricity* as a science, is truly interesting and important; but the latter much more so, inasmuch as the life and health are valued beyond dollars and cents.

For several years I have been urged to publish my careful investigations and experience in the treatment of disease by electricity, together with my new system of diagnosis, embracing new views of the philosophy of

disease — a new power by which the blood is cleansed and circulated in such a simple and concise form that the common people (as well as the educated), with a proper knowledge of a well-regulated machine, might be able to treat themselves and families for all plain or common diseases successfully. There are a few small guides (blind, however) on the subject of treating disease by electricity put out by those who have invented machines for the purpose of assisting them in selling their inventions, but who have no correct idea of the human structure; or if they have, the proper manner of applying electricity as a cure of disease has crept into their brain wrong-end foremost, judging, as I do, from what they have written as contrasted with my many years of careful experience.

Many either use the currents wrongfully, or too much inductive electricity, or both. I have been told by several under my treatment, that they had been treated elsewhere where it was used so strong as to produce a shaking of the entire muscular system, amounting almost to convulsions, and that too for an hour or two hours at a sitting. Such practitioners, it seems to me, must have but very little knowledge of the fineness of the human structure, and the tremendous potency of the electric agent to produce injury. To correct these many evils, and to enlighten all the ignorant and learned who will take the trouble to read this work, and, above all, for the special benefit of common humanity, I submit the following to a careful and candid perusal.

THE AUTHOR.

CHAPTER I.

COMMON ELECTRICITY.

THE onward cry in the march of improvement in every branch of science is resounding over the land. From the Atlantic to the Pacific, over the broad ocean and across the continent, even back again to our own shores, it is not in the least diminished.

We need only to catch a glimpse of the newly-printed page of the morning or evening paper, or the bound volume, and we are ready and eager to inquire, as the Athenians in their ancient glory did, after some new thing.

One strange, remarkable fact, however, we have long noticed with a sincere regret, that while mechanics, artizans, philosophers, astronomers, and physicians too, have thus pressed onward in certain directions to extremes, even to the injury of their mental faculties, to discover some new thing, or a very valuable improvement in the old, one subject or science more valuable to the world than any other, or even all others combined, perhaps, has been almost entirely overlooked, viz., *common electricity*. It has been thus treated ever since its first discovery by Thales, the Grecian philosopher, who flourished some six hundred years before the Christian era, as heretofore mentioned in this work by Professor Brewster.

He made some interesting discoveries, performed some experiments in mechanics, and cured many diseases that caused the more superstitious and ignorant of his day almost to revere him as a god come down among them. Then, for a period of nearly three hundred years, no advance whatever was made. After him Theophrastus, a student and disciple of Aristotle, made some few but rather unimportant additions. Then we have no knowledge of any particular advances for a much longer period. About two thousand years elapsed, when Drs. Gilbert, Digby, Boyle, Sir Otto Guerresk, Hawkesby, Grey, and a few others added a few things of importance to the science. Some time after them, the never-to-be-forgotten Newton and Franklin added more to the list of interesting facts by their discoveries and experiments than all others before them seemingly had done. Again, for quite a period, nothing special was accomplished until Professor Morse, with untiring zeal, brought out the principle of the telegraph, and, finally, harnessed electricity for his use, to the surprise and even perfect astonishment of many in sending their thoughts, and words too, upon the electric wire. He was strongly opposed, as is always the case in all new and important measures; but his strongest opponents were finally obliged to yield. And now we wonder how we lived so long without the telegraph — how we could possibly have risked ourselves to ride on a steam-car with single track, as we once did, when there was no telegraph wires, or even the whistle, to tell us of danger ahead.

But here again the investigation as a *principle* or a

science apparently stops. I have never seen, even from the pen of Professor Morse himself while he lived (and I am sure I have not from any other man), any statement as to *how* this mystery, if one, may be solved — viz., how this agent, *electricity*, subtle indeed as it is, can travel over almost unlimited space in a moment of time, and carry its message with it. This, however, is very easily explained and made clear to any intelligent mind, and which I will endeavor to do in the proper time and place.

ELECTRICITY AS A CURATIVE.

I must now mention another principle far more important than the telegraph, and which first prompted me to undertake this arduous work, viz., the use of *electricity* as a curative for the aches and ills of life. This general fact should interest mankind in proportion as the health and comfort of the body are superior to the possession of dollars and cents. I am perfectly surprised, however, to see the apathy that exists in the minds of men of science — men of high attainments in other branches of learning, some of whom have spent their lives, others their fortunes, delving after things of minor importance, while this all-important principle has been *let entirely* alone; whereas, if they had investigated it, other important matters and facts would have been discovered that would have been of great advantage to them and to mankind generally. Volumes by the hundred and thousand have been written on the various means of cure by medicines, water, and other remedies, while this principle of electrical phenomena, which is really

the foundation of all cure by any *pathy* whatever, has been almost, if not entirely, let alone. And what is the reason? we urgently ask. I answer again, *ignorance*, prompted by or from *selfishness*—sheer selfishness, I mean—and that too with men high, even upon the hill-top of science and learning in other things—men to whom we generally look for our knowledge, as a stranger does to a proper guide-board at the roadside, expecting, of course, to be directed in the right direction.

Few men ever undertake any business whatever, unless they first inquire whether they will be benefited; or, whether the undertaking, after a certain outlay, will constitute their greatest profit, directly or indirectly. If they are assured that money can be made, they will embark in the undertaking; if not, the idea or plan will be abandoned.

In the study of electricity as a science or principle out of which money may be made, little has been accomplished. Much time, and money too, have been wasted by different individuals in trying to use electricity as a motive power for machinery, that has proved a failure, which fact, without doubt, has been a hindrance to a further investigation as to its use for a higher, finer, and more important purpose, viz., a healing medium for the diseased body, or for the balancing up of the many unbalanced conditions of the human system known as *disease*.

In discussing this principle of ignorance on the subject of electricity among learned men, I have particular reference to the medical profession; and as long as they are unwilling to inform themselves, and

remain ignorant upon the subject, of course their patrons, or those who put themselves under their care, and look to them for medical advice, will remain uninstructed also. I hope to be understood here to mean not merely ignorance of its utility as a healing medium, but also of the *grand*, even *sublime*, laws that govern electricity throughout nature. My desire, also, is to be particularly understood that I intend not to assail or attack any party or pathy whatever of the medical brotherhood, only as it may be wholly unavoidable by inference, so natural among all parties where differences of opinion prevail.

My object, then, is to enlighten all parties or persons, whoever they may be and whatever may be their practices or prejudices, whether artizans, philosophers, physicians, or their patrons. As a physician among physicians, my object shall be unbiassingly to endeavor to bring certain apparently hidden truths to light, which to many of them, as well as to their patrons, have to the present time been undeveloped and unappreciated.

COMMON ELECTRICITY DEFINED.

What, then, is common electricity, beyond what we have already advanced? It is also galvanism, magnetism, mesmerism, nervo-vital force or fluid, with many other names, mostly derived from the discoverers or the manner of discovery. Galvanism was said to be discovered in the year 1791, by Galvani, then professor of surgical anatomy at Bologna; or, more truthfully, perhaps, it was discovered by his wife during his absence from home. She observed

the effect which electricity produced upon the nerves of dead animals through the accidental contact of the conductor of an electrical machine with the crural muscle and lumbar nerve of a frog's leg, which had been dressed for food, and was upon the table near the machine in the professor's laboratory. This contact immediately produced violent convulsions in the frog, which phenomena she observed and related to her husband on his return. Galvani then tried many very interesting experiments, both upon dead and live animals, to his satisfaction; hence the name of galvanism was given to this particular phenomena of electricity. Magnetism was made known by Magnes, an Ionian shepherd, who discovered it in the loadstone, or magnetic ore. Mesmerism received its name from Mesmer; it is but common electricity produced between two persons coming in contact with each other. The variety of phases which can thus be produced, is the result of the different electrical conditions of those persons, as it can be proved that all are not continually in the same electrical state, even when the general health is the same, but are unavoidably changed by the daily variations or changes of the plus or minus condition of the circumambient atmosphere which they are continually inhaling. Nervo-vital fluid is so called because it is known to demonstrate itself upon the nerves only.

SELFISHNESS THE CAUSE OF THE IGNORANCE OF THE USE OF ELECTRICITY.

The ignorance among educated physicians in using electricity as a general curative for all diseases, or

diseased conditions, arises in a great degree from selfishness. What little they may have learned in college of its common use as a curative led them to believe that to use it in general would require much more time than the use of medicine, besides extra manual labor; or, in other words, not half as much money could be earned, and that not so easy, in a given time, as could be by any other medical pathy, without taking into account whether more lives could be saved by its use. Consequently, the first class chose to remain ignorant of the potency, or rather the invaluable use of electricity as a curative, and, if so, of course the students whom they instruct must follow in their path, and are sent out over the world with nothing higher or better than the old routine of medicine in some of its special modes of administration, according to the college from which they graduated. It is easy to see why the people at large, who depend on their family physician for advice, should prefer the old beaten track of medicine in some of its forms, when told, as they are many times, that electricity may be a good thing, but that it will not do *in their case*.

I hope my medical brethren who do not exactly agree with me in practice will pardon my plainness, and that they will hear me through with as much candor and sober honesty, for the general good of mankind, as I feel in undertaking this work.

MERITS OF COMMON ELECTRICITY.

Having endeavored in some degree to show that selfishness is the great cause of the prevailing igno-

rance on this whole subject, let us proceed to discuss more particularly the merits of common electricity. Many persons do not appreciate, to any great degree, the fact of the universality or general diffusibility of electricity. They know that they can kindle a fire by the use of a little friction match, but how the process is accomplished, or why there should be such a result, they have but little idea, and are satisfied with their ignorance. Some will say, perhaps, that electricity in some way produced the fire, but whether from the phosphorus, the atmosphere, or the pine stick, they cannot tell.

We repeat again that electricity is an universal agent, permeating alike all nature, air, earth, water, and both animate and inanimate creation — no speck, space, or atom in the wide universe but is filled with it. At every inspiration we inhale a large amount of it. The food we eat and the water we drink are charged with it. You cannot drive your horse over a stone pavement on a dark night, without seeing a flash of the electric spark at almost every step.

The origin of this so-called mysterious agent is in the great centre of all light and heat, the sun, and from it is poured down continued streams of electricity, not only filling the air, but every plant, flower, and blade of grass receive their due proportion.

“It warms in the sun, refreshes in the breeze,
Glowes in the stars, and blossoms in the trees;
Lives through all life, extends through all extent,
Spreads undivided, operates unspent!”

Through these various channels of health—air, food,

and water—the system is continually charged with this vital fluid. Hence the problem is readily solved, why the use of waters charged with different mineral ingredients oftentimes effect radical cures, where a long course of medicine has failed.

AFFINITY FOR MINERALS.

Electricity has a strong affinity for all minerals, as iron, salt, sulphur, etc., but more particularly for iron, for this reason—springs of water highly impregnated with iron have cured many of various diseases, because by their use a vast amount of vital fluid or electricity is taken into the system, which, according to this theory, is the only health-producing agent.

Yet it may also be the producer of disease, and might be used so that death instead of life might be the immediate result, as has been the case many times with medicines improperly administered, or even good wholesome food when taken to excess. Ignorance develops itself in the operator because he has not taken time and care sufficient to understand the agent or principle he has undertaken to use, while at the same time the person operated upon is made ignorant in proportion to the incompetence or inexperience of the operator, and the general system is not only brought into disrepute, but doomed to be laid aside, and the beneficial effects to the sufferer lost now and forever from this first grand cause, *wilful ignorance*.

IDENTITY OF OXYGEN AND ELECTRICITY.

The identity of oxygen and electricity will be next considered together with the relations they sustain

and the duties they perform in the circulation of the blood.

Oxygen, I remark, is truly, in one sense, a compound substance, but chemists have not considered it so, since they have ever failed, to the best of my knowledge, to decompose it, and it has never been decomposed except in the laboratory of the lungs. Oxygen and electricity are not only identical, but really one and the same substance; or rather the chit, kernel, or virtue of pure oxygen, such as is contained in the atmosphere when clear and pure (not the manufactured article), is *electricity*. Electricity is encased in tiny vesicles of fluid, and when taken into the lungs, where it comes in contact with the blood for the process of its purification, is strongly attracted by the iron in the blood, for which it has a great affinity. As I have before stated, it bursts forth from its watery prison-house and unites with the blood, leaving the water to be exhaled, together with the carbon and other impurities it has extracted from the blood, which fact is patent and known to all, namely, that a large amount of moisture is exhaled always, but none inhaled, because the electricity holds it in its grasp till it is ready to dispose of it in the lungs, where it has found a more congenial friend, or where it can put itself to a higher and better use, namely, to purify the blood; the particulars of which I shall speak of more in detail hereafter.

COMPONENT PARTS OF A HEALTHY ATMOSPHERE.

First, however, I must mention, in passing, the exact component parts of a healthy atmosphere, for

the benefit of those who have not before learned the fact, or, if they have, may have forgotten. The atmosphere is most healthy when it is most dense or dry, and the current is from the west, north-west, or north, rather than from any other points of compass. And why? Merely because it is charged with more *electricity* at those times. Such an atmosphere has about twenty-one parts oxygen or electricity and seventy-nine parts nitrogen; or so near one-fifth of the former and four-fifths of the latter, that we call them thus.

When breathing such air we invariably feel brisk and lively; but when breathing an east, south-east, or south wind, when there is probably not more than one-sixth or much less oxygen or electricity in it, we always feel dull and more languid than before. Hence persons seek the hills or mountains for a healthy resort, because of the air being more dry, and of course charged with more electricity, or vital fluid, as some choose to call it, which to me is all the same. Many have even been cured of lung and other diseases by going to the mountains of Europe, or of our own country, or to the west in Minnesota, or farther west still, even to Colorado, where, we are told, the air is always dry and bracing, and because it contains a larger amount of pure oxygen or electricity, or vital principle, than is found in this level country.

. CLEANSING AND CIRCULATING THE BLOOD.

The next, but not less important matter connected with this vital principle in the lungs, is the cleansing of the blood, which is carried on at the same time. It is here, in the lungs only, where the blood is

cleansed, and not in the stomach and with medicines, as has long been the loud cry, and is yet, by many of the makers and venders of patent and other mixtures, — but more on this subject in its proper place.

Next in order, and more interesting, too, is the fact or truth that the blood is not only purified in the lungs by oxygen or electricity, but is propelled to the extremities of the system and brought back again by the power contained in the lungs through this agent — electricity — and not by suction or hydraulic pressure of the heart, as the books and modern physiologists tell us, or would have us believe. And why? Merely because of ignorance on this subject of electric force they have not discovered anything better.

In order to be more explicit, as well as to make myself wholly understood by those who are not much acquainted with the *old, rusty, irrational*, as well as unphilosophical theory of cleansing and circulating the blood, I shall be obliged to use a little argument abstractly.

The best physiologists and anatomists tell us that a common-sized healthy man has about three gallons of blood in his system, and that this blood performs its circuit through the entire system once in about three minutes. Allowing for the very small quantity that moves very sluggishly through the capillaries and corpuscles, — if we may be allowed the expression, — there still remains enough for the general circulation; so that about fifty-six gallons, or nearly a hogshead of blood, performs its circuit every hour of our being, which may be true. Furthermore, we are told that to perform this great work, it requires a motive power

of fifty tons, or one hundred thousand pounds' weight or pressure, which may also be true. But that this great work is performed or carried on by the suction or hydraulic power or principle contained in the heart, a little muscle weighing less than one pound, cannot be true, and must be false. A more monstrous libel, or more absurd idea, never obtained publicity than this. A dozen of the very best inventors from this or the old country, with all their ingenuity combined, could not invent a machine of the very strongest metal, of the size of the heart, that would not be torn to atoms before it would sustain one-tenth part of that pressure. Yet this is the philosophy taught in the books and medical schools of Philadelphia to-day, while I am writing. Why could not rational men have seen this *monstrosity*, this great inconsistency, *long, long* ago, and not have propagated such an absurd principle, even to this enlightened age and people of the nineteenth century? No other or better reason can possibly be assigned than the one already given, viz., a morbid willingness to remain ignorant. Such ignorance with regard to so important a principle, and universal as well as useful agent, when studied and understood, as it may or can be, I deem wholly inexcusable.

But to change my base from the abstract to the concrete, I remark first that this great work or motive power is contained in *electricity* alone. Many are aware of its extreme subtlety, but not of its great motive power when properly harnessed. We can only measure it by its results or effects on our senses. To be more explicit, I remark, secondly, that the

lungs are kept continually plus or positive by the electricity of the atmosphere. The blood, coming into the lungs from the extremities of the system through the heart in a negative or impure state, is cleansed or changed from this purple and impure condition to pure or positive blood; and as two positives cannot remain together, but must repel, the blood thus changed and positive is repelled and forced over to the left ventricle of the heart into the aorta, and thence into the smaller arteries to the extremities of the system, the heart doing just the work, and that only, it was designed to do by its great Designer and Maker, viz., to regulate the circulation of the blood, and not to give any motive power whatever; doing just the work, and that only, that the pendulum of a well-regulated clock does—regulates the power or pressure already applied, which indeed is a very important as well as responsible work. The auricles and ventricles are so constructed as to permit only just so much blood to pass at one opening and shutting. They can be made to work faster or slower, like the valves of a pump, according to the pressure in the lungs, as is manifest when a man is engaged in hard work, or has been running until his breathing is very rapid, and a vast amount of this motive electricity from the atmosphere is taken into the lungs in a short space of time; the pressure then, of course, is greatly increased, so as to cause not only rapid, but heavy motion of the valves of the heart, such as we all have experienced many times. The blood is thus forced through the heart and onward to the extremities of the system, where we find it, after passing through the capillary arteries

into the veins in an impure negative state, having lost its red color and entire positive electrical condition on its outward passage from the lungs. At this particular juncture, modern physiologists will agree with me. But how, we ask them, is this negative blood to be got back again? No satisfactory, rational way is given in the books even, nor taught in any of our medical colleges to-day. A few unphilosophical forces are laid down and taught in the books, which are unsatisfactory to themselves or authors, and they leave the subject by saying that it is not clear how this part of the circulation is performed. For our part, we think the latter about as clear and as rational as the former, knowing that the two circulations must exactly balance each other, in order to avoid congestion; that the blood through the veins must return to the heart with the same velocity or force that it went out through the arteries, as the two never mingle. But here is the puzzle they have ever been in, and out of which I will soon lead them, if they will candidly follow me through.

The blood, as before stated, at the extremities of the system, is in an impure negative state, just as it should be for our purpose and theory. The lungs, remember, are always positive. This negative blood is, then, of course, attracted by the positive lungs, so that it commences its march first slowly back to the lungs; but as it comes nearer home it is more strongly attracted, of course, until it goes bounding along towards the heart, passing, as it does, through the right ventricle for equal distribution again into the lungs, where it is again cleansed or oxygenized, but

more properly electrified and rendered pure and positive, and again sent out as before with the same velocity — attraction and repulsion, as before stated, being equal.

Some interested persons say that my theory is very fine, indeed, if it were feasible, or if some good proof could be advanced of its correctness. True, indeed, *but please be fair and honest*. Why ask proof of my theory, when none has been asked of the old and inconsistent one laid down in the books, and to-day taught in the schools and colleges of this our proud city, Philadelphia, as being correct? One thing is very clear and indisputable, — that the starting-point of the circulation of the blood is not in the heart; that the depot, if any, is not there. The *old* theory agrees with us that the blood is cleansed in the lungs, and rendered pure or red and positive only there, which goes far to prove also that the power or principle contained there to cleanse or purify it, may be also the same to start its motion and propel it forward. This indeed is true. It is sent forth through the heart, which only opens and closes its valves as a common pump does for the water to pass through it which has been forced there by the power of the lever, the heart acting at the same time as a *regulator* of the circulation.

Another asks this question:— How do you know that the blood is negative at the extremities? I answer, first, that fact is self-evident from its appearance or color, being in an opposite state or condition from what it was when it left the lungs; and, secondly, known to be so by analyzation, as every chemist knows who has tried it.

Another natural and very interesting proof will now be added. We asked an advocate of the old theory, one day, while discussing this subject, why there were small nerves laid all along the arteries, and none along the veins. He replied he could not tell, as there were other things about the circulation not well defined or made very clear. "Well," said I, "then you would like to have us tell you, if we can?" "Oh, certainly," he said.

Here is, indeed, a very interesting point, which I shall endeavor to make plain and well understood, viz., to show how this grand *animal-machine*, this wonderful galvanic battery each and every man possesses, is being continually charged for his special use, in order that he may be able to carry on such a vast amount of business during the tedious hours of mental and physical *labor*.*

* REFUTATION OF MRS. EMMA WILLARD'S THEORY OF THE CIRCULATION OF THE BLOOD.

After the above was written, and the book in press, I was explaining to a publisher my new theory of the circulation of the blood, when he remarked that my views resembled the "Willardian System," as explained in a work recently published, entitled, *Art, Literature, and Science*, by Mrs. Elmira Lincoln Phelps, a sister of Mrs. Emma Willard. As found on page 298 of this book, the subject is there called "Circulation by Respiration." This is, indeed, the beginning or cracking only of the shell, without tasting of, or finding even, the kernel. Mrs. Willard's theory is in one sense *right*, and in another *wrong*. The blood, indeed, as I have explained above, receives its cleansing and accelerated velocity *through* respiration, but not at all *by* it. She has indeed made a strong assertion, and set forth a theory without a particle of proof, and why? Because her premises were wrong; she did not start right — just as you cannot prove a problem in algebra or Euclid because you have not just the right figures in their right places in the statement. On page 302 it is further asserted that "respiration causes heat." That is also correct. It is then asked, "what causes respiration?"

There are myriads of tiny nerves all along the arteries for the sole purpose of inducing the electricity from the blood as it passes to the extremities, which are connected with the great sympathetic nerve in the spine, and thus, of course, with the brain, or rather with both brains,—the cerebrum, which controls our thoughts and actions, or all voluntary motion when awake ; and the cerebellum, or back brain, which controls or regulates our digestion, circulation, respiration, and all involuntary motion while we are asleep or in an unconscious state. The electricity we get from the food we eat and the water we drink does not

which question is not answered, but Mrs. Willard continues by saying: "My simple explanation is that caloric coming in contact with the blood in the lungs warms and expands it, and by its expansive force produces movement, and the fluid, seeking to find space, rushes on through the pulmonary veins to the heart, and thus on to the extremities of the system."

This theory is indeed more rational than the *old*, but as it is it fails for two unavoidable reasons :

First, if the blood be expanded in the lungs by caloric, or the natural principle of expansion of fluids, the force is equal in all directions, and it would be natural and just as easy for the blood to be thrown backward in the lungs as forward, and suffocation with immediate death would be the inevitable result. The theory thus destroys itself.

The second and greatest mistake Mrs. Willard makes, and which she cannot avoid, because of her premises being wrong in the outset, is in getting a power to bring the blood back again from the extremities of the system, for the venous and arterial circulations being equal, the motive power that constitutes both must be equal, of course—there being no steam-engine or additional caloric there after the blood has passed from the capillary arteries to the capillary veins, and become negative, as we there find it, to drive it back again.

This theory, it must be perceived, is no better in this particular than the old threadbare system ; but the true principle of circulation is thoroughly explained and made clear by my theory of equal balance through the positive and negative forces of electricity.

benefit us directly from the stomach, where they were deposited, but by a mysterious net-work connection of transverse nerves connects with the great sympathetic nerve of the spine, and thence conducted to the brain for the use of the body through the agency of the mind, about which I have as yet said nothing. Now there must be a general depot or magazine somewhere for deposits. Indeed there is.

OFFICE OR USE OF THE CORPUS CALLOSUM.

The mind, that immortal, imperishable part of our existence, holds this great controlling power of which I am to speak. It wields its sceptre at will, and if the man-machine is in good working order, it moves him or causes him to be quiet at pleasure — only, however, through its willing and ever obedient servant, electricity. The mind, as you know, cannot leave its destined throne — it merely holds out its sceptre and directs. Where, then, we ask, is the exact place or deposit, or where is this servant electricity to be found? We answer not in the *cerebrum*, nor in the *cerebellum*, nor in the brain at all, but in the *corpus callosum*, an organ at the base, or near the base, of both brains, and for which no particular use in the books is assigned — a discovery of the use or office of the *corpus callosum*, the seat of the eternal mind, hitherto unknown to scientists, and unexplained in the books. There, and there only, in our opinion, is the throne or citadel of the eternal mind, and the exact place where the vital forces of electricity are basined up for its particular use, and can, by nature's laws, be readily called forth, whether we are awake or asleep. Many under-

stand, in some degree, what a power the mind has over the body, and yet know little or nothing, perhaps, how that power manifests itself, as it does sometimes, so wonderfully upon any portion or organ of the body when called there by circumstances. The mind, as before stated, is not a movable thing to any portion of the body; it is, without doubt, stationary. Then what is? Electricity, certainly, its ever obedient servant, going instantly wherever the mind chooses to send it. It can be made to act upon the digestive organs in general, or upon any one organ in particular. For instance, many persons cannot look upon an obscene or exceedingly filthy object after eating a hearty meal of good wholesome food without its making them sick in a very short time, and causing them to vomit, which is a common and well known circumstance. It will also act just as readily upon the nerves and muscles when, by a change of circumstances, it is called there. One example only. A lady patient of mine, whose back was not strong, related to me the following: She said she was riding in a carriage in the northern part of our city, and about crossing the Germantown railroad track, when suddenly a locomotive with a train of cars came round a curve with a rush, and passed swiftly by in front of the horse and carriage, so that the driver, she said, had to turn the horse one side a little to escape, as she thought, being hit by the passing train. She said she did not move in her seat, as she could not for the fright at first, but as soon as they saw themselves all safe, untouched and unhurt, of course, her back commenced aching fearfully. She said, if it had been twisted once entirely

round it could not have felt worse. She was obliged to keep her bed for several days on account of it.

What are all these examples but actions of the mind upon the body through this wonderful agent, electricity, as its servant? We might add much more upon this topic that would be of interest, perhaps, to the seeker after health, or the best way to avoid disease, but will dismiss the subject for the present with the addition of one thought, viz., How apparent, then, is the fact, in order to have a vigorous body, that the magazine, the store-house for vitality, or electricity, should not only be just where it is, in the right place, but that it should be like our granaries or cellars for a long and tedious winter — well filled, and, if possible, kept so?

IDENTITY OF OXYGEN AND ELECTRICITY AGAIN.

A few words more with regard to the identity of oxygen and electricity. Many proofs may be adduced, if we had time to dwell upon them. We shall only mention one, which, we think, for our purpose, will be conclusive.

An experiment like the following has been performed, which will prove two things. A healthy animal was slain, and two quarts of the blood caught, being, of course, about equal parts of arterial and venous blood, and each quart put into separate bladders; one was hung up where the west or north-west wind blew briskly upon it, the other quart was placed in the laboratory, where the air could not much affect it, and where a primary current of electricity from a proper battery was run directly through it. In the

course of an hour or so the blood in the bladder in the air was quite changed, from a dark to a florid or red color, on the side where the wind blew on it, and in as far as the influence seemingly penetrated only; while the other, through which the currents of electricity had passed, was wholly changed into red blood, and in less time, too, than an hour, as in the other case. This goes not only to prove, in the first place, their identity, but also that electricity from a proper battery, as well as from the atmosphere, would do the same thing in cleansing the blood and rendering it positive.

ELECTRICITY AS DEVELOPED IN INANIMATE NATURE.

We will now turn our attention for a few moments to common *electricity* as developed in *inanimate* nature.

The *sun*, that great luminary in the heavens, and the centre of our solar system, is the source of all electricity, and is continually distributing a proper quantity to all the different planets under his control—first, to give them motive power for the performance of their different circuits; and secondly, to vivify and give life to everything belonging to their surface.

How beautifully, then, does he prove himself to be the life-giving principle to the world, beholding, as we do, in the opening of spring, everything opening into life from the long and apparent death-sleep of winter, caused by the absence of this now welcome messenger. Thus we see the earth not only turning on its axis so accurately once in twenty-four hours, and also swinging in its orbit around this great electric centre every year, by the positive forces of electricity, and thus

performing such magnificent gigantic works, but we see the myriads of tiny insects, as also the little seeds long buried in the cold earth, all showing signs of animal and vegetable life by one and the same agent. *Electricity*, then, without doubt, is the great source of life to the world of matter, to the animal and vegetable kingdoms, causing all the multifarious changes visible to our *senses*.

We hold, then, that electricity, coming as it does from its great centre in the heavens, the *sun*, acts in concert with nature in producing life and vitality out of that which before was all cheerless and dead, apparently, and thus not only causing all nature herself to look so beautifully as well as move so harmoniously, but it also acts just as readily negatively, or in the opposite direction, in producing disturbance by throwing the elements out of balance, as is seen oftentimes by the gathering of the dark and portentous storm-clouds, when the muttering thunder in the distance gives the warning that the elements are again out of balance.

The hurricane sweeps along with such velocity as almost to lay prostrate everything before it, in its haste to restore the necessary equilibrium in some portion of the globe where the vacuum had been produced. But now the storm is passed—all is still again. The equilibrium is restored, and a healthy state of the atmosphere is the result, as we have many times experienced. The immediate life-giving or vital principle of electricity imparted to vegetation in various ways is doubtless very great.

A brief notice of one very simple discovery, which

was afterwards tested by experiment, must suffice. Some few years ago a peasant in England observed in his garden that one hill of potatoes grew much taller and looked much more thrifty and healthful the whole season than any of its neighbors on the same soil, and with only the same attention or culture, and found, when harvested, to produce a larger quantity, as well as better quality, but could discover no cause whatever, except on digging down considerably below the roots he pulled up an old rusty iron hoop. Not satisfied with this, the next year he tried it on two or three more hills, in different localities, and found similar results. He then communicated the facts to a good chemist, who, after several tests and experiments, concluded that it must be from the extra amount of electricity from the atmosphere attracted there by the iron, for which it has a peculiar affinity. To test it a little further, another, and little different but more accurate test was tried, by planting a continued wire under one entire row of potatoes, and leaving every other row without any — all on the same soil, and the same or similar results were manifest in the fall when the potatoes were harvested. It was decided that it was the soft iron wire which attracted a continuous current of electricity from the atmosphere, which also caused a greater amount of moisture to be secreted there, leaving the soil more light and arable. Since then it has become quite a common practice in that country among gardeners, where soil is more valuable than it is here.

The above is only another proof, as you see, of the independent vital power of electricity.

CENTRIFUGAL AND CENTRIPETAL FORCES.

Leaving this quite interesting phenomena, or vital demonstration, of common electricity, I am obliged to hasten to say a few things concerning the two prominent forces known as plus and minus, or positive and negative, and which constitutes attraction and repulsion. By these two forces all nature is not only balanced, but kept in balance. And in doing so, I must necessarily make a short warfare upon old and stereotyped opinions laid down in the books of our common philosophy taught in the schools years ago, and for aught I know to-day, while I am penning these lines, as I have seen nothing yet in print to the contrary. I refer now more particularly to the moving of the planets of our own solar system, or rather to the power by which they are moved, kept in motion, and in their own respective spheres. Professor Brewster, in the former part of this work, has referred to this fact, but by no means is it made clear and distinct there.

We know they are effected by two forces, which is doubtless *true*; and those two forces are called in the books *centrifugal* and *centripetal*, which is *not* true. When in my academic course, and studying my natural philosophy about those two forces in nature regulating the motion of the earth and other planets, I was never satisfied, and had several disputes with my teacher about those unmeaning terms, as well as forces, — centrifugal and centripetal, — being anxious to know in what they consisted, or how they might be defined in order to make the principle understood, but was ever turned away without an

answer, except that it was mysterious or God-given forces, and the matter always remained mysterious until I found out the principle by a careful study of the laws of electrical phenomena, which, when understood, makes it so plain we only wonder that it has remained a mystery so long.

THE EFFECT OF THE TWO FORCES.

We will notice more particularly the effect of the two forces, or rather their concert of action upon our own planet, the earth, in its diurnal motion, which, perhaps, will be more easily understood. One significant fact concerning the laws that govern electricity, when once understood, is, they are never known to change or vary. And why? Because they are the laws of nature, and made by an infinitely wise and changeless being. The earth turns on its axis once in twenty-four hours, and never varies or changes — never gains or loses any time. But where exists the power that does this great and hitherto called mysterious work? The books fail to inform us. They say it is God's work, and therefore mysterious. This is true. And so is our being — so is the growth of a blade of grass or corn. God's works are mysterious in many respects, even in these last facts, simple and plain as they may seem. And we have arrived at plain and self-evident causes that produce these effects. But what with regard to the other? What turns this mighty globe around with such tremendous velocity, as well as accuracy? I answer, it is done by attraction and repulsion, or, in other words, by the combined positive and negative forces of electricity

acting continuously upon it from the great electric centre, the sun. It will be remembered that the sun is nearly vertical at the equator, only varying some twenty-three and a half degrees either way, and of course shining directly, or nearly so, upon one side of the earth, and thereby rendering it positive, while at the same time the opposite side is in darkness, as at midnight to us, and, of course, electrically in the opposite state and negative. Then, as positives always repel each other, the greater conquering or repelling the weaker, the earth being fixed, immovable as to its position in its orbit, and being, as we suppose it to be, like a ball hung upon two axles, it must of necessity commence turning round, even if it were before standing still, just as a water-wheel does when water is turned on one side of it. Then, as it turns over, a negative side is brought towards the sun, which, by the positive sun is strongly attracted, so that we have the two equal forces, attraction and repulsion, like a rope round a pulley, acting upon it to give it a rolling motion, which never has nor can vary as long as God sees fit to continue it.

This is only one instance in which some of his grand, natural laws are made known to our senses. Another is shown us in the exactness and harmony manifested in the laws that give and govern the motion of all the planets of our solar system, not only on their own axis, but in their circuits or orbits around their great centre, the *sun*. The unmeaning terms of centripetal and centrifugal forces, which have no force of themselves, and nowhere to go to borrow any, we ignore and throw out entirely, and substitute

others, viz., positive and negative, which are real, which have a foundation or source in electricity, and that emanating from its great inexhaustible fountain, the *sun*. This is something tangible or real — something we can understand when we talk about it.

The earth in its aphelion is in a negative state to the sun, and of course attracted by it; in its course towards it, its velocity is very much increased, as well as is its positive electrical condition, (just as we grow warmer ourselves, or more positive, as we approach a fire when cold,) until it becomes equally positive, for the time being, with the sun, which is the case when the earth is at its greatest perihelion, or at its nearest approach to the sun. Then it passes round the sun, coming only just so near and no nearer, because it cannot on account of its equal positive state, but is thrown off again in its orbit — the positive sun acting upon it for a time to send it along in its course. In going away, however, from the sun into the cold region, it begins slowly to lose its positive state, and also its motion, becoming more and more negative, as well as being now attracted again by the sun, until it is finally turned round at its aphelion, as before stated, because of the attraction of its great positive centre, the sun, towards which it is again attracted.

What I have now said about our earth, or the laws that govern it, may as truthfully be said about all the other planets of our solar system.

WHY THE PLANETS KEEP THEIR PLACES.

Another very interesting thought here introduces itself. I am asked how, in my theory, I reconcile the

matter of each planet keeping its place — the larger ones far outside of our earth, and away from the sun, and the smaller ones inside, and much nearer to him, of course. This is a matter not clearly or satisfactorily accounted for by the old theory, but very easily with this. What I have before said I would here again repeat, that a thorough study and right understanding of the great law of equilibrium, which governs electricity in its positive and negative conditions in the great world of nature or of matter, as well as in atoms that make worlds, will, in all cases, make everything clear and easy to be understood, without a particle of mystery, as has hitherto been entertained, concerning its phenomena. But ignorance makes mysteries anywhere and everywhere.

It will be remembered that I stated, in the beginning of this work, that although electricity was a universal agent, filling every substance and spot in creation, yet some bodies and substances were capable of containing much more electricity than others in the immediate neighborhood; that this was regulated by different densities — the most dense bodies contained the most electricity. It is well known that the planets of our system are of different density, this being of absolute necessity in order for them to keep their places in their spheres. If I had time I would specify the exact density of each. I will merely add that the little planet Mercury has a comparative density in connection with its bulk (which must always be taken into account) to place and keep it, by this same grand law, just where it is, in its nearness to the *sun*. Mars and Venus are governed by the

same laws, and so on outside of us, until we reach the farthest one known to our astronomers. It is because these grand natural laws cannot be violated that these have not varied from their spheres, and thereby come in contact with each other.

One fact more only, I must notice in passing. It will be remembered by many, perhaps, that in the fall of 1858, or about fifteen years ago, I think, there was a brilliant comet, which made its appearance in the north-west very suddenly and unexpectedly, even to our astronomers, and which created no small excitement among the people. Many things were said and written about it. One individual more wise, or who considered himself so, made out, by a careful calculation in figures, that a more providential thing, perhaps, had never happened since the world was made, than that comet crossing the earth's orbit just when and where it did; stating that if the earth had been twenty-four hours later in its orbit or course round the sun, we should, in all probability, have been dashed to atoms or to *chaos*, as this earth once was. We were not as well posted in the laws that govern electricity then as now, or we would have given that article a passing rebut. It is very clear, however, that that sage did not, by any means, understand the grand laws of equilibrium produced in nature by the equal or positive and negative forces of electricity as demonstrated by, or through, attraction and repulsion.

Suppose, for instance, that the great and wise God and Maker of all worlds had made a small mistake at that time, and allowed this fact to have taken place, and we on our earth had been in the direct line

of this comet. Why, according to this law of electrical equilibrium, we, in our approach to each other, would have obeyed that law, that is, whichever was the most positive would have given off to the other, until the equilibrium or balance had been produced, then each body would have gently swung a little out of its direct course, sufficient to pass each other, and instead of being dashed to atoms, we should not even have felt a sensation sufficient to have spilled a drop of our coffee, if we should happened to have been taking a cup at the time.

It is not certain but we may have been in the exact line of that comet, from its very sudden and brilliant appearance, as there are some four hundred or more of them that are passing and repassing our earth's orbit without any very definite time of their appearing; but for all that, we need not indulge in the fear of any injury until this grand law of electrical equilibrium is allowed to be broken by the all-wise God who first made it.

ELECTRICAL ACTION UPON THE ANIMAL ECONOMY RESUMED, WITH NEW DISCOVERIES MADE.

It has already been distinctly shown that there has been a great failure, on the part of men of science, in observing the laws that govern electricity upon inanimate nature, which fact has had a very great tendency to cripple their knowledge on other important subjects, and more directly connected with the object before us. *Ignorance* — my watchword at the outset — ignorance, I say, from a failure of investigation in the universality and general diffusibility of

electricity, creates all the great mistakes made to its unalterable laws, as well as power, in the work it is now silently doing, and has been doing, in the world of animate and inanimate nature, ever since Adam was first placed in Paradise. Physiologists and anatomists have ever been puzzled to rightly understand from whence this motive power came to carry on the work of animal economy, and hence made great mistakes, as before stated, with regard to that exceedingly important principle, viz., the circulation of the blood, and finally conclude by saying that after all they were in doubt about it themselves. It is very easy to arrive at wrong conclusions when we have first started wrong, and not only wrong in regard to the particular thing aimed at, but wrong in other side issues that may be more or less involved or connected with the whole machinery. For instance, the use or uses of the spleen is to-day not understood by professors of anatomy, or those who have written on the subject, as there is nothing in the books that gives us any satisfactory idea of its use, or for what purpose it was put into the body. Some two years since, one of our first and best city surgeons, who ought to be posted on such matters, stated to one of my patients, who had just been a patient of his, that this organ, the spleen, which he considered in his case the most diseased, was really a useless thing; or, in other words, it was not known for what purpose it was put into the body except to give a man trouble. That was indeed a grave charge upon the great Designer and Maker of us all, that He had made such a mistake as that, in cumbering us with such a promi-

ment and worse than useless organ in our formation. The gentleman, nor his sage predecessors, would not have remained ignorant of so vitally important a matter so long if they had investigated or studied more closely the principle of motive power in the animal economy, and found, as they would have done, that power to be *electricity*, engendered in the lungs, where, and only where, the blood is cleansed, and where it receives its momentum, that propels it with such wonderful velocity, even to the very extremities of the system, where, by a change in its condition, caused by its passage outward, it is brought back again to and through the negative portion of the heart to the lungs by the same equal force as I have before sufficiently explained. I repeat, then, emphatically, that if old prejudices had been laid aside, so that new things could have been seen and properly treated, as they should have *been*, new discoveries on the subject would have been made long before, and there would have been no difficulty in finding out the proper office and uses of the spleen.

We will now endeavor to show, as we think we can, to any and every unprejudiced mind, that the Almighty Maker and Ruler made no mistake after all, and that the spleen is not only far from being a useless thing in our organism, but an organ without which man could not survive.

Remember then, first, that in the lungs this great motive power that circulates the blood is engendered from the continued inspiration of oxygen or electricity. When we breathe as we ordinarily do, our circulation, together with the pulsations from the heart, are all

regular; but when we labor hard, and use much strength, or run a long distance, or ride a hard trotting-horse, or even get excited in any way, so that respiration is much hurried, and a greater amount of electricity, or this motive power, is thus inhaled in a given time, and the lungs thus rendered unusually positive and heated, the blood, of course, is sent out with more force, and a greater quantity in a given time upon its regulator, the heart. And as the heart, with its valves, is so formed that only just so much blood and no more can pass at one opening of its oracles or valves, there must be some way to escape the approaching inevitable ordeal—congestion and death. These valves are capable of increased action according to the amount of pressure from the lungs, and can endure it for a short time without any material injury; but after they are worked to their utmost capacity, and there is still more blood from the continued, and perhaps increased, force from the lungs than can possibly pass through the valves, what would be the inevitable result but death from congestion or suffocation, unless a way had been provided by Him who makes no mistakes?

Here comes to our aid, then, this very indispensable organ and agent, the *spleen*. This we call a sort of sponge and reservoir, into which the blood in such cases can slowly recede or soak away, and for a time remain quiet, or until this extra pressure is taken off (which will not be long, for it usually creates more or less pain while there), when it can return, or go back again to its proper destination. The spleen being in the left side, upon or against the fundus of the stomach, and

extending towards the back, is quite out of the way, and, like a reserve fund to a bank, only necessary and always ready when in health, and wanted for the express purpose for which it was created.

There are not regular veins or arteries leading the blood to and from the spleen, but there are infinitesimal ducts or leaders through which the blood in its pure state (as it then is) can slowly pass in its ingress and egress to and from its destination. For a simple proof of this theory, I will mention one common circumstance, which many of our readers will doubtless remember to have experienced in their youth, if not in later years, viz., after running a long distance, or swiftly for a short one, or riding a hard trotting-horse so as to set the blood in violent motion, they were attacked suddenly, and severely too, with a pain in the left side, when, by stopping the exercise or the hurried breathing a few moments only, the pain would gradually subside, and by pressing the hand gently on the side it would pass away sooner. This pressure empties this *sponge*—*spleen*—sooner than it would be emptied without the pressure.

More proof might readily be added to substantiate our theory, or the position taken with regard to what we consider the real, legitimate, and only office of this organ, the spleen—the discovery of which was made by the careful use and observation of the effects of the electrical current upon the human system in my experience for the past fifteen years; but the proof already offered is positive, and the facts self-evident. If a better and more rational theory can at any time hereafter be produced for the use of the spleen, I shall

be happy to give it my attention and candid investigation; but until that time I shall be satisfied to stand firmly upon the ground already taken.

UNSEEN VITAL FORCE.

What has already been stated on the general subject of this unseen, vital principle, electricity, with regard to its diffusibility, its unchangeable laws, how in the universe of nature it causes not only the change of seasons of heat and cold, storm and sunshine, is very readily understood when properly investigated, seeing that it is caused by merely a change of polarity—namely, what produces heat in one part of our earth produces the same degree of cold in another, or in the opposite direction, and *vice versa*. Now the human system is but an epitome of the universe of nature; or, in other words, man is a universe of himself, acting in one sense in and for himself physically, as he does truly in many ways financially.

For example, we would refer once more to the natural elements, as I wish to have this part of our subject distinctly and wholly understood. Nature herself becomes diseased by a real change of circumstances electrically, or by the changes of her electrical polarity, and for a time everything is in confusion. A dreadful, fearful hurricane passes over us, lays everything movable in her course prostrate; but by another electrical change in her power all things come to rest, and she is cured of the disease or difficulty by another and opposite change in her polarity. And this is not at all mysterious, when carefully studied and wholly understood.

It is just so with man as a universe of himself. To-day, at this moment perhaps, he may be all quiet and well, feeling no inconvenience whatever ; to-morrow, or the next hour perhaps, he may be all out of balance and convulsed, diseased apparently from head to feet — this vital, unseen principle all deranged, and the man soon going to ruin and to death unless a sudden favorable change takes place.

How very many instances like the following : A person in health, apparently, eats and relishes a good, hearty meal, rises from the table, takes a seat in his easy-chair, with his newspaper to read, and in ten minutes he is approached, and is found to be dead. The vital spark, that living principle, has fled. The electrical balance, in his case, was not merely disturbed, but, from some cause, its channels completely clogged, and of course life became extinct at once. This, however, is only a solitary instance — one phase in which this principle is developed. Cases innumerable might be instanced to show in how many ways disease may be discovered by merely this electrical balance first becoming disturbed. Enough, however, has already been stated in this connection.

IMPROVEMENT IN THE TREATMENT OF DISEASE.

Up to this point I have been treating upon things and principles that are to compose the building, and should wholly fail of my object or purpose if I should stop here and not attempt to show or point out clearly, if possible, the building itself, or how it is really designed for the benefit of all who may chance to read or hear what I have written.

My final object, then, as stated in the outset, is an improvement or reform entirely in the diagnosis and treatment of disease for the good of all mankind. This is not a theme altogether new, yet there are new and vitally important ways of getting at and really accomplishing valuable aims and ends.

I am very sure, also, that many will agree with me that the time has fully arrived that some improvement be made, if any can be, in the treatment and cure of acute as well as chronic diseases, from the old routine of medical practice, and from any and all poisons as remedies, if any such discovery has been made. And for me, now, to doubt this fact, will be next to doubting my own existence. This fact or principle I have been testing and proving for fifteen years or more, to my entire satisfaction, and oftentimes to the surprise of many who have witnessed the cure of disease as if by magic or miraculous power. For instance, to stop and break up a severe case of typhoid or typhus fever, after it was once seated, with the pulse up to one hundred and twenty per minute, and causing a profuse perspiration, that continued for twenty-four or forty-eight hours, or until the fever was subdued, with only one, two, or perhaps three applications; or to cure a case of pneumonia and pleurisy in one or two treatments, which we generally do. Even old chronic cases are oftentimes cured very suddenly. At one time I cured a case of chorea (St. Vitus' dance) of eighteen years' standing with only two applications; at another, straightened a little girl's spine with only one treatment, and in each case they remained so, and the cure permanent. Many others, incurable with

medicine, I have cured within the last fifteen years that have required a longer course of treatment, and have continued well and not relapsed into the old state again, as we hear sometimes our opposers have erroneously reported.

OPPOSITION FROM WITHOUT AND WITHIN.

Electricity has had the whole array of medical practitioners, both of the old school and the new, with a few honorable exceptions, and the combined force of medicine-makers and venders, with their millions of blind adherents, with which to contend. Still it has withstood all this wonderful array, and even grown in strength and in favor with the people, and especially with quite a large class of the more intelligent, thinking ones, who have become disgusted and sick of the practice of dosing the stomach with nostrums to heal or cure a disease somewhere else.

But with all this array of opposition without, none has been so formidable as that from within—the enemies of its own household—the many who have been using it without first having thoroughly studied its peculiar laws, or rather the laws that govern it.

Many physicians, as well as others, have done and are doing the same thing to their patients, who have, with confidence in their knowledge of electricity as learned men, had it applied perhaps for a few times to no apparent advantage, if not as an injury, and then abandoned it. The failure, of course, laid to electricity, instead of to the bungler or ignoramus who ventured to apply it. What progress could a teacher make in teaching Greek and Latin who had

spent all his youthful days studying English studies, and become a thorough scholar in that department, but had never studied either of those dead languages? Just none at all. Or what could a carpenter do towards building a house with a trowel, brick and mortar, or a mason with carpenter's tools and pine wood? Just nothing at all,—simply because they had never learned how to work with such tools and materials. They can each build houses, but they must have the tools and materials to use with which they are acquainted, and had before learned how to use.

Just so, emphatically, with my medical brethren from the medical schools. They spent their time until they graduated in the study and use of medicine as a curative, and since they have been in practice they have used their best judgment no doubt in its use and adaptation for the cure of their patients, while electricity was left untouched as a curative, and much more so as a thing with which to discover disease. It was used in college as a sort of plaything for sport or experimenting in certain cases, but not studied at all as the all-pervading agent of the universe, that gives or takes life everywhere in nature. If a cure is made at all by medicine, it is only the result of a favorable chemical change in the system, which change is the effect of the proper adaptation of a positive with a negative, and this again is the direct result of a plus and minus current of electricity as the prime mover, which is capable of a full and clear demonstration. Ever since I first located in Philadelphia, some twelve and a half years ago, I have been urged, from time to time, by persons who

had made themselves acquainted in some small degree with my system of practice, to write and publish some work on the subject, and send it out to educate the people in general. The very thing, indeed, I have been anxious to do, but the time and labor required could not possibly be spared from my already over-taxed energies, and the matter has been postponed till the present. Even now I shall be obliged to abridge my desired plan somewhat on account of unavoidable circumstances.

Familiarity with anything, or principle, always lessens its worth or interest to us, however valuable it may be, or however much we may have been interested in its first discovery or introduction. I well remember the first car, drawn by one horse, for the conveyance of passengers, that was ever used, I believe, in the United States, and ran between Albany and Schenectady, in the State of New York, how much was said about the convenience of it at that time. But that was soon forgotten. I also remember the first use, to any particular advantage, made of electricity was the invention of friction matches, called then *Lucifer matches*. This was in 1837, thirty-six years ago. They were first made of pine whittlings, the ends dipped in a preparation of sulphur, phosphorus, and emery, and then were drawn through two pieces of sand-paper to ignite them. They were sold at twenty-five cents per box of fifty. This was then considered as one of the great discoveries of the age. Next came the percussion-cap, instead of the old flint-lock, to fire-arms. In many other ways, from time to time, electricity has been

harnessed up for use, being found running wild everywhere and in every place, and for the use and benefit of everybody when wanted, until finally Professor Morse made his discovery, which is now being used to so much advantage not only in our own country, but nearly all over the world.

But how unaccountably slow did the people move to assist him, or even to notice his discovery. He had exhausted his energies of mind and body, together with his entire fortune, even to the last dollar, and was about to give up in despair, when finally Congress reluctantly stepped forward and appropriated a small sum, sufficient to put up one wire from Washington to Baltimore for a trial, which, to their astonishment, proved a complete success.

Although electricity has been used ever since the days of old Æsculapius, or more than two thousand years ago, to some extent in curing, it has been mostly experimental until now, or within a few years.

The time did not seem to have come, as there seems to be a time for every new thing to develop or be developed. This was the saying of the wisest man, Solomon, and it has been the result of our own experience, if we note carefully the past.

But now it seems very plain to me, and has for the past few years, that the time for a thorough medical reform has come—that the *allwise Creator* of the universe is, in a multitude of ways, making known to mankind how they may get rid in a measure of the evils that sin has engendered. And He seems to have chosen these United States, or the more enlightened people of America, to be, in many

instances, the discoverers, or rather, more properly, the setters-forth of His long and deep-laid plans. But we have to be content with a slow movement, especially when we have a strong power against us, as well as great obstacles directly on our track to clear entirely out of the way, as is the case in the universal sale and use of medicines of all kinds.

We were nearly one hundred years engaged in putting down the slave power and giving the bond-man his freedom — a thing considered impossible by a very large majority of our people, among whom were some very good and conscientious men. Yet it was determined and persevered in first by a few, and at last accomplished almost to universal satisfaction.

Very soon after I established myself in Philadelphia as an electrician exclusively, there was a very worthy and highly-educated physician, belonging to the society of Friends, who had practised medicine some forty years or more in Philadelphia, came to me and said he was desirous to look candidly and honestly into my system of medical practice, or rather of cure by electricity alone — said he had read carefully my circular, and had heard of some of the cures I had made with electricity without any medicine. After an interview, he expressed a satisfaction with my theory and a desire to have a course of instruction, which in due time I gave him. In the course of my lectures, I explained to him the new theory of cleansing and circulating the blood by electricity only as the motive power, together with other new facts and principles as the direct result of these new discoveries. After he got through the course, he

acknowledged himself very much gratified indeed, and fully satisfied that I was right in my theory, and concluded by saying that I would have to be very patient and wait for the people — that I was at least fifty years ahead of the times, and that the people would or could only be brought slowly to believe and embrace the doctrine to be true and practical, which he really believed they would do in time, as he now did himself.

ELECTRICITY A SPECIALTY AS A CURE.

We have come, finally, to what was my first object in the commencement, as well as through the whole of this argument, viz., to bring satisfactory reasons for the adoption of this new system of treatment as a specialty, together with the advantages that every physician, as well as his patients, would derive, in more ways than one, from the exclusive use of electricity as a curative agent.

In the first place, then, and as a first reason for its adoption by physicians, it is reliable as an examiner; and secondly, to administer, it is a specific for all acute conditions. Neither of these can be said of any medicine whatever. Again, all medicines, or all doses given, whether great or small, contain more or less that is poisonous, and of course operate against nature to destroy in part the vital force, even if a benefit is afterwards obtained, while *electricity* is this vital force, or vitality itself, and, when properly administered, commences with the first application to add to that natural vital force instead of depleting or taking it away, as is the case with medicines. For instance, I

have seen many cases, under the use of medicine, and have been twice in the same condition myself, when the patient was so far gone, or this natural vital force so nearly exhausted, that there was not enough left upon which the medicine could act, and of course it could not be given. The doses of course were withheld until the patient either rallied or was left to die. Not so with *electricity*. It has been and may be used with astonishing results in the most extreme cases — it has, in many instances, even brought still-born infants to life that would have never breathed without its use.

In several instances I have been called to use electricity only as an experiment for adults who were apparently just about expiring, who had been under the use of medicine for weeks, and could take no more — the vital spark just about departing, when, by a gentle current of electricity, warmth, or the vital force, began again to develop, by which an increase of the circulation was generated, and in a few days the patient was up and convalescent. The reason of the phenomena is perfectly simple and clear, because electricity is not a stimulant, as some pretend to call it — an ephemeral, lasting for only a moment — or like good bread and butter and beef, which produce vitality as any healthy crude material does, but it is vitality *per se*, *in* and *of* itself, when properly and skilfully applied.

Disease of whatever kind, as I have before said, and which I here emphatically repeat, is only an unbalanced condition of the vital forces in the man-machine; or, electrically, that is, there is merely too much electricity in one part and too little in another, and

that is enough to produce great evil — even the destruction of the whole machine in a short time — unless the change is speedily wrought. And how much sooner, and effectually, too, it can be accomplished by a proper electrician, who fully understands the human system, and can readily locate the disease, as well as administer the proper remedy, and no guesswork or guessing, nor feeling of the pulse, after the old style, being necessary.

A very prominent reason why electricity has not been adopted more readily by the people in general for acute or common diseases, is, because they have ever been instructed by their family physician, in whom they had confidence, that it was only good for old, chronic cases; or, in other words, for conditions only that he, their physician, had become weary of, and that he could not cure, and, of course, glad in any way to get rid of them. Some physicians are honest, however, having never seen it applied for fevers, dysentery, diarrhœa, pleurisy, or inflammation of any kind. In fact, the standard medical works teach the same doctrine, viz., that electricity must never be applied when there is any inflammation, whereas that is our *sheet-anchor*. Nowhere can we make such astonishing, such almost miraculous changes and cures as in the most acute, inflammatory, or congestive cases imaginable, from any cause whatever.

If I am to prove what I assert, I must be allowed, in this connection, to relate a fact or two of my own experience. A lady of rank and respectability, Mrs. J. G——, was attacked with congestive pneumonia, having taken a violent cold. She had two of the best

old-school physicians, who used their utmost skill for two weeks, but in vain. They then pronounced her incurable. Her husband, almost frantic with the idea of losing his beloved wife, called to inquire of me whether there was a possibility of any benefit from electricity. Calling to see her before I could answer his question, I found her apparently struggling in the agonies of death, with no natural pulse — merely a sort of quiver at the wrist — the breathing very laborious, and so short that her breath scarcely entered the lungs at all — feeling, as she afterwards expressed it, as though one hundred pounds weight lay upon her chest. This particular sensation was the result of protracted congestion and inflammation, producing strictures or stoppages in the entire lungs, even to the bronchia. I commenced carefully to cut away or remove these first, and give room for deeper inspirations, if possible. In five minutes, only, I saw indications of improvement. She then opened her closed eyes, her inspirations became longer and not so laborious, and in twenty minutes could quite fill one lung and the other partly. Soon after she ventured to whisper, so as to tell us that she felt very much relieved, when I left her for the night. I saw and treated her twice the next day, and found her very much improved, and in ten days had her out riding in her carriage. She was soon perfectly restored, and has enjoyed excellent health ever since. These were the facts.

Now how was this change and cure made so as by magic, almost? Because, seeing at once where the enemy was located, I sought to dislodge him, which,

by proper treatment, was done, to the utter astonishment of her friends and attendant physicians. The inflammation, of course, had induced a high fever, which I subdued in the meanwhile with the treatment. The medicine she had taken to relieve her of her pains and distress, and to quiet her, had produced great constipation of her bowels, so that they could get no motion, even by cathartics; this I also soon overcame by the treatment, which astonished them all about as much as anything else.

One more case only I will mention, and a very different one — that of inflammation in the brain of a lady on Walnut street, the result of a severe attack of puerperal fever, ten days after her confinement, and also given up as past being cured by her physician, who is one of the first homœopaths, perhaps, in our city. I arrested it soon, and got her up and out in only two or three weeks after I was first called to see her, though in her usual health she was always quite delicate. It was also thought the babe could not live, caused by the weak state or condition of the mother — it was made all right, and is now a bright, healthy child.

I have obtained similar results in many other cases of congestion and acute inflammation, such as fevers, bowel complaints, bruises, etc., in all of which they had first tried medicine without success; and when hope had about fled, electricity, as an experiment, was resorted to, which soon brought a favorable change of their condition, and restored them to health, with only a few proper treatments. I might fill a volume in recital of similar, or even more interesting cases of

cure, where I had been called in the beginning of the attack, and was obliged to make only three or four visits; but I forbear, expecting that if these fail to convince the incredulous, or stimulate them to make a trial, any more evidence would be useless. Mankind, we know, are bound not to be drove; they are to be led or coaxed, and if a few well-prepared morsels fail to do it, a whole loaf would, from the same principle.

I have not, nor shall I, in this connection, say much, if anything, with regard to the cure of diseases in an opposite state, or of a chronic nature, for physicians and others concede the fact that electricity has and does cure those conditions, though medicine does not, while in many instances it even aggravates or produces them.

After so much of plain, and apparently convincing argument, it seems that every unbiassed person cannot fail to give it a trial, as many already have done, and are doing. The change in the minds of the people on the subject for the last few years is very great indeed. Twelve years ago, or when I first came to Philadelphia, there were only one or two in this great city using it, and that on a limited scale. Now there are more than twenty different ones, besides medical men (I know not how many) that are using it—I wish I could say scientifically, but I cannot say that in truth. Hence the reasons for my writing what I have to educate the public mind to look candidly into this matter, and, from a conviction of right and duty, to think as well as act for themselves, and not from what they have heard Mr. or Mrs. A B say that C, D, or E had told them, or, what is quite as com-

mon, what their family physician, who could tell them many truthful things about medicine, but not about the use of electricity in their case, because, as I stated before, of ignorance on the subject themselves. And when the blind undertake to lead the blind, both, of course, must fall into the ditch. I am friendly not only, but on the best of terms, with quite a number of medical men of high standing, and no reason why I should not be with all, and would, were it not that mankind are so supremely selfish. Some, however, of the more liberal and honest ones have given me a key that unlocks some of the serious objections to their adopting the treatment, and using it as a specific in out-door practice.

FORMIDABLE OBJECTIONS IN THE WAY.

First and foremost of all, stands the matter of criticism from the brotherhood, and persistence would be expulsion, of course, from the *ring* or *circle*. There are a few, however, who, from unavoidable circumstances, have been obliged to look the matter squarely in the face, and I know now of what I affirm — it is my own experience, where I have come unavoidably in contact in the same house, and in several instances in treating the same patient, with these very physicians of both schools, and where they have been obliged to see the triumph of electrical over medical treatment, and been forced to acknowledge its supremacy or advantages over medicine. Some such, I say, have frankly acknowledged that, although my treatment with electricity alone seemed to be adapted to acute conditions, they could not after all adopt it, as it

took too much of their time, and too much labor was required in its application ; — in other words, there is not, as they supposed, so much money secured in a given time, seeing that three times as many calls, or twice that number, can be made in the same time when only a prescription is to be given. Then, again, the patient will be cured much sooner with electricity than with medicine, and, of course, not as profitable in that particular. But such reasoning is all *bosh* and *folly*, if I may indulge in such a homely expression, and I have only used it to bring to view a few plain, simple facts, or foolish surmisings, that lie below the surface of medical practice. Such reasonings, however, are neither honest nor truthful, and will not bear thorough investigation.

DUTY BEFORE CIRCUMSTANCES.

In the first place, then, every professional man, and more particularly the medical man, is bound to yield all prejudices to honest convictions of duty. If more lives can be saved, and more misery avoided, by one course of procedure than by another, that course ought to be adopted, by all means, or at all hazards, regardless of any and all circumstances. Taking labor, or money to be acquired, into account, life and comfort ought not to be sacrificed for either. These conclusions, however, after all, are groundless, for every good enterprise or business, when properly undertaken and prosecuted, will always regulate itself. More money can actually be made by the physician, and more saved by the patient, by electrical treatment, while, above all the rest, more lives saved, by

one hundred per cent., from acute inflammatory attacks, than by any and all of the medical practices combined, when properly undertaken and prosecuted; but not by *empirics*, however, who have not first learned thoroughly the principle, and had some practice.

I have used the term *selfishness* quite freely, and, as I believe, truthfully, and where it belongs; still it would not be strange if, after what I have said with reference to the superiority or preferment, in every particular, of electrical over medical treatment for all acute diseases, and all inflammatory attacks, as well as for chronic cases, that I may be charged with acting from the same motive myself, viz., *selfishness* only. But this I unhesitatingly and emphatically deny. First, I would not, to increase my business, because I have broken down and been obliged to close my office three times, for months together, from overwork and close confinement, since I first came to this city. Secondly, I cannot be doing it to benefit any others using electricity, for I have hardly a speaking acquaintance with any other person or persons using it in our city — a mere sense of unavoidable duty from a strong conviction that the time has fully come for something to be done to enlighten the people and subdue blind prejudice. I have repeatedly had pressing solicitations from friends also who, from the knowledge they had of its superiority over medical treatment, by its application to themselves or their friends, to write and circulate a work for the enlightenment of the people, and the medical profession also, on this new and all-important improvement in curing the sick.

I might say many more things of importance to make my argument and reasonings more clear and understandable beyond what I have already written. But I am in haste to have it before the people, together with this work of Professor Brewster, which is very fine, and which precedes what I have written. And as he knew and wrote nothing on the subject of using the principle which he labored very hard to bring out, and which indeed is a labored and masterly production, though only theoretical and not practical as far as relates to the benefit of mankind in the treatment and cure of disease, I thought it not only proper, but absolutely necessary, to have the one accompany the other. In conclusion, then, of the first edition of this work, I have but one important thing to add, and that is a word of caution. And I really hope my motives may not be impugned in this particular either; but if so, I must discharge the duty.

A FEW WORDS OF CAUTION TO ALL.

Candid reasoning men, and women too, after carefully reading this work, will doubtless decide that as for them they will give the new treatment a trial. And as I have not asked any individual to come to me for treatment in all I have said or may say, yet I would come short of what I desired in the outset, if I should fail to administer at least one small dose of *caution* to any and all who are about to give it a trial. It is said of electricity that it is so simple that any one can apply it—it does not require much study, etc. I do not deny that a person who has any common share of

mechanical genius about him may learn in a short time to set up a battery and apply the current to the body, and, for some conditions not intricate, produce good results. I have known of many such instances, and that was my own experience in the outset of my career as an electrician, and in a few weeks, or months at most, I thought I knew fully all there was to learn about it. I truly had made some very interesting cures, even those that medicine had failed to cure. But experience ere long taught me that I had only learned the initiatory steps, by finding out contrary results from those anticipated, and which were only discovered and remedied by experience with deep and close study.

Of course, I had no books or instructor to go to, as there were no books then, nor are there any now, published on the subject of proper treatment. There are indeed many small works, put out by machine-makers and venders in order to enable them to sell their machines more readily, yet I have seen none but what, even with charity, I can only call blind leaders of the blind, because they contain, as far as I have examined them carefully, more error than truth. And a great evil is oftentimes avoided, or a great good achieved, by only understanding so as to notice the small changes for good or evil which are often entirely overlooked, except by those of great experience.

To expect, therefore, from electricity what I have assumed, you must apply to no empiric for treatment who has not had much experience and does not understand his business, whether he be an M. D. or not. To be sure, yours may not be an intricate case,

that will not require much investigation—a plain case and apparently easily treated; but you do not know that of yourself. It may even be a very intricate case, indeed. I say then, do not even apply to a regular medical man as such, unless you are satisfied that he has studied the principles of electrical science thoroughly, as he probably has that of medicine, and has had some time to put what he has learned into practice, as very few medical men from any of the schools have done; for they thus far have preferred using the remedies with which they are most acquainted, and, as before stated, which require the least time and labor in their use. When your family physician says to you (as many have done to those who have desired the use of electricity) that, if you really want electricity, he can give it to you, or he will bring his battery and let you apply it yourself, as you can do it just as well, and no harm done and no cost either, just mark him as an empiric or ignoramus in that particular, and knows not what he is doing, or he would not do it; for he might as well leave his medicine-case with you, and tell you to help yourself—take what you please, as much and as often as you think best; or send you to the drug-store, and tell you to help yourself to the first bottles you find.

But in either case he would be far from doing it, because medicine is a subject of study and more or less experience with him. He knows too well what serious consequences have resulted from its injudicious use. Just so in many cases it has been, and would be again, with electricity improperly administered;

whereas, when properly used, it is not only perfectly safe, even to the infant or very sensitive person, but it is without the least shock or pain, and to most persons pleasant and soothing. The greatest and most common evil, resulting from a wrong or improper use of electricity, is the failure of a healthy change or a final cure, and the consequent disappointment both to the patient and friends. If medicine has failed ten thousand times where it has been used, it makes no difference — it will be tried over and over again; but if electricity is resorted to *once* and failed, it is laid aside as good for nothing. And these failures will occur even with electricity, if not scientifically and judiciously applied. For instance, a few years ago a prominent physician, who was very friendly to me and my practice, said, one day in our conversation, that he thought very favorably indeed of my system of practice, and that he had used electricity in many instances for two years or more, but added, it is not reliable — I get good results sometimes; at others, and upon similar cases, I do not; and I have thought or feared that it might have been injurious. Said I to him, “Sir, may I plainly tell you the reason?” “Yes,” he replied. “Well, sir,” said I, “you have undertaken to use tools you know little or nothing about. You have doubtless used the positive pole where the negative was needed, and *vice versa*.”

He then and there acknowledged frankly that he did not know one from the other, or that there was any difference in that respect, when the difference is as great as two opposites can possibly be — one producing heat and the other cold; one contracts, while

the other expands, when applied to the same organ, nerve, or muscle; one pole, at certain times, would sicken and cause a vomit, while the other would, in certain conditions of the stomach, act as a cathartic. Hence, while the right one, in the right place, would readily cure perhaps in one application, the other, and wrong one, might readily increase the pain or difficulty, whatever it may be.

Finally, I submit what I have written on this part of my subject to the candid and careful perusal of all who may think proper to give it their attention, and hold myself ready to hear any reasonable criticism, as well as answer all rational objections, from either friends or foes.

CHAPTER II.

INSTRUCTION.

I HAVE finally decided, and now proceed to write and put in print, as an appendix to the foregoing volume, what varied circumstances have kept me from doing for the last twelve years, or ever since I commenced treating diseases with and lecturing upon electricity in Philadelphia, viz., a synopsis of my discoveries and experience of the manner in which I treat all common phases of disease, and which I have been compelled, as it were, to do for several important reasons.

First, because I have, in many cases, promised this work at some future time to those of my students who have taken a course of instruction, and gone out to different places to work, to refer to whenever any intricate case might come up for treatment.

The above promise was made in good faith, to be fulfilled in due time. One very prominent reason, however, for delay was that the people were not ready, or that the time had not really come for the people generally to be the most benefited by it; and even now I have only been convinced of the duty for so doing since I commenced and almost completed what I have written with regard to the general subject of electricity as a curative agent, and, in my

estimation, not only the best, but in fact the only curative, whether from medicine as an agent, the atmosphere, or a well-regulated battery, which is by far the best when understood and properly applied. Many pamphlets or small volumes have been compiled by machine-makers and venders, and sent out with the machines in order to introduce them among the people, which, as I believe, have had their day, or sufficient time to convince the people that there was some virtue in electricity, but that there was, after all, something lacking somehow or somewhere, and that eventually there would be something better and beyond what had yet been discovered, and would be brought out by those who have had opportunities of thorough practical experience. This is merely a plain matter of fact to all in any legitimate branch of business or science, and particularly of any new and untried thing. This fact, with regard to electricity as a general curative, however, has pushed its way forward, so that many obstacles are being removed.

Another thing of no small importance, and in favor of putting before the public a short treatise on treatment, is that I can do it much easier, as well as cheaper, for much I would then have to say as preliminary is already said in the preceding pages, and will abridge very much what it would be absolutely necessary to state on the general subject of electricity, and of disease as connected with it, either to create life or to produce death.

One thing more of considerable importance I will add as an inducement to my doing this now, viz., to avoid being charged—harshly, perhaps, by some

parties — for finding so much fault not only with medical men, but with all employers who are using electricity not according to my ideas of science and right. I hope, now, in this to be understood that what I am about to lay before the public is mainly for the good of the people — good and even lucrative to those who will study and judiciously administer it according to proper rules, and particularly good to all the diseased who may be so fortunate as to have it thus administered to them.

I shall endeavor to show, in as plain and simple a manner as possible, the better way, by far, of curing disease, not by an M. D. particularly, but by an *E. D.* — one who is well educated, whether man or woman, and desirous of getting *good by doing good*.

That is, I mean to say that it is not necessary for a person to be an M. D., or have that title, in order to be a good electropathist, while, at the same time, I would emphatically state that no one can be a successful electropathist unless he understands the structure of the human system, which he may readily acquire by study. But a long course of lectures on medicines is of no use whatever, but rather injurious to make an efficient electrician. And why? Because the starting-point to cure by medicines and by electricity is not the same by any means. To treat with medicines, you can only arrive at symptoms in your diagnosis. After questioning the patient as closely as possible, you charge your gun and fire, then wait to see whether you have hit the mark; if not, guess again, and make a similar trial. By a diagnosis with electricity, we arrive at facts at once, and need not

make a mistake. True, mistakes are made, I hear, by professed electricians; but they who make them are only *charlatans*. They have not learned their trade well, or if they have, they have not had the practice to make them proficient, and the cause suffers, as every new and good cause does, by unskilful pretenders.

Let me add that any careful, judicious person, male or female, with an ordinary education, who thoroughly and understandingly reads this whole work, may safely use it upon himself or herself to great advantage, and, with a careful study of common (Cutter's) physiology (if not well studied before), would be better prepared to treat all diseases, as they are found among mankind, with more certainty of success, than any medical physician *is* or can be with medicines, though he may have had the experience of a lifetime.

OTHER MODES WITHOUT THE USE OF THE BATTERY.

Before commencing to give the first chapter of instruction on the proper use of the battery, I am reminded that the reader will be much advantaged by my describing in brief other modes and ways by which people are benefited and cured with electricity without the use of the battery, and that, too, when they do not know it, and the credit is ascribed to some other agent, while electricity receives none of the credit. Indeed, I should do great injustice to my subject, or the grand phenomena of electrical action in general, if I did not define its use as a cure in more forms and ways than as administered from a well-regulated battery; for it will be remembered

by all who have carefully read and understood what has been stated, that electricity is really and truly *omnipresent*, or universally distributed throughout nature, or wherever our common atmosphere can possibly penetrate. It is found in all liquids and solids; consequently, whenever we are situated so as to come in contact with it, we cannot help but be benefited in degree according to kind, manner, or quantity taken into the system.

And as I have thoroughly tried its use and adaptation as a cure in removing disease, in all its varied forms, from the system before I adopted my present plan as being the best, I feel myself fully competent to give what every rational, unbiassed person will call good and satisfactory reasons for so doing. Being at liberty, then, to change or adopt other systems of using electricity, or connect their use with my present practice, it cannot be from wholly a selfish motive, or aside from the general good of mankind, that I am about to show how different individuals are often using and being cured by electricity when they were not aware of it.

THE MOVEMENT CURE — MINERAL WATERS.

My mind was called to the importance of making a note of this fact, a short time since, by reading an article in one of the morning papers in which the writer was extolling very highly the new movement cure, mentioning particularly its increasing popularity. This, as every scientific person must readily see, is nothing more than *common electricity* from friction. It is bringing into exercise the muscles that pass

across and through each other in various ways, and which are all brought into use by different motions, movements, and gesticulations, according as the patient has strength to make, or endure them from others. There is but one class of persons that would be benefited by this sort of electrical treatment, viz., those who are too rich or too poor, or unable to work from other causes, thus failing to bring the muscles and vital organs of the body into exercise.

Hence the advantage of being able as well as willing to labor in-doors or out of doors, where there is plenty of fresh air, which is made up largely of electricity; or if labor is to be performed wholly in-doors, then have as many doors and windows open as possible.

I suppose many who have been benefited by the movement cure have hardly an idea that they are cured by the warmth or vitality caused by the friction of the muscles, or from contact with the hands of the physician in rubbing the patient, which is only a mild current of electricity, nothing more.

Another mode of receiving it is from the bath — whether Turkish, Russian, or the common bath, it makes no difference. Water is always surcharged with electricity, and contains that agent in proportion to the quantity of mineral substances it may contain. Consequently those who use water upon the surface of the body, followed by frictional rubbing, receive, in part, the advantage of the movement cure in connection with the electricity absorbed from the contact with the water.

I will not take more time in explaining these different

modes of supplying the system with this vital force, but conclude by stating one more feature in the use of water alone as an element by which an excellent electrical effect is produced on the system, and important cures are made by electricity as the agent.

Water is always surcharged with electricity, but, like other substances, is not all alike in its composition, and of course possesses electricity in different degrees. Some may possess no mineral properties, comparatively, being purely soft, while others are highly impregnated with mineral substances. These minerals, by their inductive capacity, render the water capable of retaining a large amount of electricity. Iron, for instance, is very susceptible to electrical influence, so that water containing much iron in its composition, when drank, or applied outwardly to the body, imparts much electricity or vitality. Water impregnated with salt always produces an exhilarating effect, or adds vitality to the system by increasing its natural electrical force.

Having briefly noticed the beneficial results of electricity by friction produced in the movement cure, which has already obtained some celebrity in the city of New York and elsewhere, and also from the various kinds of mineral waters, I shall only notice, in passing, the effect produced by an atmosphere surcharged by electricity.

ATMOSPHERE, EARTH-CURE, SUN-CURE, ETC.

Our friends are benefited by inhaling the salt air at the seashore, without going into the water at all; it is because of the large amount of electricity which,

by inhalation, is retained in the system. Some go to the mountain-tops of our own or the old country, where the air is not only dry, but invigorating, as it is termed, merely because in these localities it contains perhaps double the amount of this vitalizing force, *electricity*, that it does here, and of course double the amount of vigor is imparted to the system in a given time.

There are still other ways of securing the advantages of this wonderful vitalizing agent, electricity : — one, called *terrapathy*, or *earth-cure*, by applying clay or earth to the body ; another, the *sun-cure*, by exposing the patient to the rays of the sun, in some peculiar manner. This, I am informed, has been practised to some extent, with good results, in France.

Those of you, my readers, who have followed my reasonings carefully, will see that in all these various ways only one result is at last obtained, and that is the *vitalizing force*, which is nothing more nor less than *common electricity*. What, then, permit me to ask, is the *finale*, the *ultimatum*, and unavoidable conclusion of the whole matter, which must be proven clearly to the satisfaction of all candid reasoners, that the thing sought through any and all of these various channels, and obtained in a greater or less degree, is the vitalizing force that tends to quicken and invigorate both mind and body ? That vitalizing force is this unseen, mysterious, wonder-working agent, *electricity*.

The next and last thing, and one of greatest importance under this head, is to know which is the easiest, cheapest, and best way of obtaining it. With the advantages of many years of careful observation and

experience, I unhesitatingly reply, through and with a well regulated battery, administered by an experienced operator, and who is well acquainted with the physiological structure of the human system.

WHAT THEN IS DISEASE?

Disease, I here repeat, is a unit, and the system out of balance electrically, or the electrical, which is the vital force, more or less deranged. This one disease is divided into two grand parts or divisions — the one where there is too much electricity, and inflammatory; the other where there is too little, and paralytic, or below a par value in proportion as the other is plus or above. In order to rightly understand what I am now about to say with regard to the proper treatment of disease, you must first have not only carefully read, but re-read and studied thoroughly what I have already written in this work on the subject of the circulation of the blood, as well as about disease in general — my opinions differing very materially from other medical men, or what is written in the books upon these two particular topics, arrived at or discovered only by the careful study and application of electrical law and its adaptation to the production of animal life in the economy of nature. And further, that this unmeasured and mysterious force is not only capable of producing life through divine agency as supreme, but by only a small change in circumstances, hereafter to be explained, it as readily produces death and decay. This change, or these changes, are produced by only a slight change of the plus or positive with the minus or negative currents of electricity in the system. I

remark, therefore, that the plus or positive and the minus or negative battery currents are exactly adapted to the positive and negative conditions of the human body, or the animal economy, in producing these desirable and very necessary changes. My whole experience on this point for sixteen years, is one continued chain of facts and certainties, which, when learned and understood thoroughly, are not only grand to contemplate, but sure and invariable in their results when properly carried out—not a single link in the whole chain broken or misplaced.

The operator has only to carefully diagnose the case or subject he is about to undertake to cure. First, then, I emphatically state, be sure what he is about to do or desires to accomplish, and the work is already half done; in other words, do just as any good mechanic would do with an important job of work he is about to perform—first look at and through it, or until he is satisfied he knows what is needed, and how he must commence in order to accomplish his desires fully, and the work is already half done, and he will pursue his plans understandingly, expecting, after a certain amount of labor is performed, and the expenditure of a certain sum of money, to accomplish the desired result. Much experience, however, in either case is of very great advantage. When I first commenced treating with electricity indiscriminate cases as they came to my office, I had no instructor nor instruction books to refer to that were of any great value, and only about six months of private practice on myself and family, together with a few of my immediate friends and

neighbors, and, of course, had to feel my way along as best I could, like a man walking blindfold or in the darkness of midnight. I treated many of my first patients gratis, in order to get them to try it at all. I first learned that by carefully examining with electrical currents I could discover that there was something wrong or different from healthy persons. This I learned in part, however, in first practicing on my own person for some weeks previous to using it on any one else, as I might have stated in its proper place that it was the loss of my own health that led me first to the discovery of its use. I had a partial sunstroke that laid me aside, which finally, after some months of confinement, and which medicine and water both failed to cure, culminated into an extreme case of dyspepsia and nervousness, and brought me to the borders of the grave; and when my friends and neighbors were daily looking for my departure, the Lord from heaven seemingly said to me to try *electricity*, and directed me just how to begin its use. As soon as I got strong enough to get about with some degree of independence, and the people began to find out what had been the agent in doing such a great work, I had many callers as inquirers concerning this new and mysterious agent, and how the matter was accomplished.

But to pass by this apparent digression, I opened my office to treat all cases and conditions of disease, as my confidence then was fully established that it was superior to medicines of any kind, and even superior to water, which I had used as a cure for fifteen years or more with great success, previous to

my sickness, and which I considered far better than medicines, but which had signally failed in this instance. In every instance I examined carefully with the electric currents in order to discover what the condition was, as well as to know what was necessary to be done, together with asking direct questions of the patients as to how they were made to feel while under the treatment, and afterwards taking critical notes of all facts of importance to be remembered. By experience, however, this has long ago become unnecessary.

In the second place, then, I remark, we want to pattern after a scientific mechanic in another sense, viz., to be sure always to get the best of tools if you expect to do a good job; and in the third place, be sure you not only learn well how to use them, but to keep them in good working order, and always ready for use when needed. More about the tools, however, and what kinds are preferable, by and by. Commence, I repeat, when all other things and appendages are well understood, by first carefully examining your patient with the negative pole of your battery, and after you are fully satisfied that you know *what* the trouble is and where located, commence the treatment *similia similibus curanter*, that is, by the application of similars, viz., put one pole of the battery, wrapped in a wet sponge, under the feet, or let your patient sit upon it, as is most convenient, the latter being the better way generally, and then apply the other just where the disease seems to be most apparent—the plus or positive where, by your careful diagnosis, you find it to be plus or inflammatory, and the minus or negative pole where you find it negative, insensitive to a certain degree, or below a natural or healthy state.

What, then, is to be understood, more particularly, by these terms of *plus* and *minus*? Why the *plus* means more than a proper, healthy condition, where there is already too much heat or electricity above a par value, and inflammatory; while the *minus* is directly the opposite state, with a lack of electricity or vitality; or, to be still more explicit, and make this very important point too simple to be misunderstood, I repeat, in other words, or terms, the same idea — that the nerves, upon which, or through which rather, no blood, nothing but electricity passes, when in a plus or positive state, are surcharged or overcharged with an undue proportion of electricity, creating, of course, great heat, while the minus is in directly the opposite state, and rendered diseased from a lack of the proper amount of heat or electricity to give natural warmth and sensibility to that particular organ or part of the system. It is certainly, then, very plain, as well as philosophical, in order to supply this lack, to apply the negative or minus pole (a similar, as you see) direct to the part, or place, just long enough, as well as often enough, to supply the deficiency, as positives always run to negatives, no matter how much obstructed or how circuitous the route, or how distant — even across the Atlantic and under the bed of the ocean, if the conductor is a perfect one.

A GREAT ERROR.

Here, however, for the enlightenment of the student or reader, I am constrained to stop to notice one of the greatest errors imaginable — an error propagated, and spread broadcast too, by a professed electrician

of some note — one who styles himself not only *professor*, as that is but a common title and used by carpet-shakers, but an M. D., and has published a work on electrical treatment. The book, I am informed, has quite a wide circulation, and has been purchased quite extensively by beginners in the use of electricity, who bought their instruction for ten dollars each. The error consists in the fact, as this professor teaches, that the positive does not go entirely to the negative, or rather, that they meet each other on the way is what is meant to be understood; or, in other words still, that if there be a part in or outside of the body, either in a positive or negative state, that you wish to influence or rightly treat, you must shorten or lengthen one of the conducting cords, as the case may be, in order to do it. I knew this same error to have been embraced and taught some dozen years ago or more, by a certain electrician, but I had supposed it to have exploded long ago, or until, perhaps five years since, a particular friend of mine, whom I had not seen for a year or more, and while at the West had been paying some attention to the study and use of electricity, came to me and stated that a great discovery had been made in the application of electricity, which was considered of very great value, and which he was willing to communicate to me gratis as an electrician. I listened, of course, attentively to the matter, and found it to be nothing more than that very old error revived again, carried out West, and palmed off upon him for money as a very great secret. I asked him where he got it, as it was second-hand; he replied from the professor aforesaid — the same

which I read afterwards in the book referred to above. I frankly told him it was an old error, laid aside by me years ago, and in a few words explained to him the impossibility of such a thing being true, which he readily saw.

If it were true, as you will see at a glance, our messages would only go half or part way across the ocean, as the case may be, which would be entirely contrary to all experience in telegraphy; and what is true and proven in electrical law in one sense is true of all, for it is a natural law, or a law from God himself, and therefore cannot change. In the sixteen years or more of my careful experience, in ten times ten thousand ways, I have yet to find the first change or variation in this grand fundamental law, about which I shall now say something more definitely, to wit: the first law of electricity is for it to select the best conductor, no matter how circuitous or lengthy the course. For instance, it will go round the entire globe on a copper wire, or any good conductor, before it would skip an inch through the atmosphere, merely as a conductor, to save distance to its destination.

Its next law is to run in a direct line, and take the shortest course when the conductors are equally good. Consequently, the human body being a very good conductor, because of there being so much moisture in its composition, as well as being so compact withal, an experienced electrician can direct the current upon and through any internal part he may choose, though not larger than a dime; so that by placing the negative pole or conductor on any organ of the body, knowing that positives always

seek or go directly, as well as entirely, to the negative, and not part way, as some have very erroneously taught, you have only to place the positive on the opposite side to reach that identical spot, and it will affect any organ or part directly in line between the two poles. Again, with regard to these grand and unchangeable laws, my system of treatment is from direct polarity — that is, if I wish, in a special manner, to benefit any particular organ of the body, I have only to place one pole upon it, or as near it as possible, and the other upon the vertebræ of the spine, whence the nerve that leads to that organ emanates, and in that manner, or by thus first polarizing, you can effect more in one treatment than may be effected in half a dozen ordinary *hap-hazard* treatments, or such as are given by many calling themselves electricians, or even as many medical men have done and are now doing, viz., taking their battery to the sick-room and leaving it with their patients, and telling them to use it themselves. Oh, horrible! Much or little, just as they choose or feel! What folly; yes, *madness!* Almost every day or week cases of this kind come to my ears. And can you blame me for strongly rebuking such a practice? Oh, that there were a law in this direction, also, to protect the innocent, who have placed themselves, as they suppose, in the hands of those that understand this principle as they do about their medicines.

INDUCTIVE CURRENT.

The next very important matter to be remembered is the use of a very small inductive current. Much is

saved in strength and unnecessary exhaustion to the patient when this principle is strictly observed. And what I mean by the induced current is the increase of sensation by a large coil of wire, or the current broken by interchanging often the large and small wires in a small coil, which makes always a very harsh current.

THE RIGHT WAY OF APPLYING THE CURRENTS.

Again, as the natural laws that govern electricity never change, so the right way of applying the currents to cure disease never change — always remembering that you must apply *similars*; that is, to a plus or inflammatory condition apply the plus or positive pole, or, in other words, the repelling force or current. And why? Because it has already too much electricity there, and disease has begun because of it, and now the right and only way to get rid of it, as an enemy doing already its diabolical work, is to treat it as an enemy by a sufficient positive force that will repel or dislodge it and cause it to retreat.

On the other hand, if the part or organ be minus and diseased, because of a lack of this vital force — *electricity* — and of course weak and of a chronic nature, it needs to be nourished and strengthened with an addition of electricity to the part. To do this, apply *similars* again, viz., place the negative pole there, and as the positive always goes to the negative, as before stated, you get the desired result. And by repeating the same at intervals from time to time, you restore the part to an equilibrium, which is health.

By fully understanding and properly applying and

carrying out these few plain and simple rules, according to this grand electrical law of nature, you will find, after you have had some experience, no difficulty in giving good and careful treatments—those that will cure any and all curable diseases, most of which have been found incurable by medicines, and frequent repetitions of such applications only are necessary to make the operator or physician not only familiar with, but successful in curing, as he never before found himself to be with the use of medicines.

Those general rules I have already given for treating are amply sufficient for all diseases, either acute or chronic, if carefully observed and properly carried out. But in order to assist the new operator or beginner in his work, and help him or her to get started rightly, and with less danger to the patient as well as embarrassment on his or her part, besides making this work a text-book to refer to when necessary, I will here introduce a few

FORMS OR EXAMPLES FOR TREATMENT

Which I, in my beginnings, and with much patience, was obliged to work out without any text-book or guide whatever, except the use of the sponge instead of the bare pole or metal button, then in common use, and as used still by some operators.

The first case, then, we here introduce, is a person attacked with pleurisy, which of course is a plus or positive state or condition, with too much electricity or heat, and in a feverish state, and to be materially changed or mitigated in order to give relief. The patient has great pain in the left side, and oftentimes

so severe as to materially affect the breathing. This can be cured with only a few proper applications — sometimes with *one*, if taken when the pain first becomes severe; first, by putting the negative pole at the coccyx or under the feet, and applying the positive pole, wrapped in a wet sponge, directly on and around the part, for five or ten minutes, when the pain is most severe, and the same treatment in an hour afterwards, if the first did not give relief; and so repeat until relief is obtained, which is never beyond three applications — and the same applications precisely for colic pains, or pains any or everywhere in or upon the body. It is also just as efficacious for burns, applied in the same manner.

Then, on the other hand, when any part or organ, or even the whole body, is found, by a very careful examination, to be in the opposite state, and negative, or below the par value—that is, with less sensation than a healthy state—it needs the negative pole applied, in order to supply the lack of electricity which it needs to bring it up to health and natural vigor.

This last case is the general condition of all persons afflicted with any chronic disease, and a few of the first treatments in such cases must always be given in a similar manner as last described, using the negative pole all over the body, and particularly on those parts that are slow to feel or yield to an ordinary current, in order to vitalize or bring them into natural or even anything like healthy action or sensation. By thus doing you open the capillaries, and bring or restore lost action through them to the surface of the body.

After this has been done, to go on and complete

the cure, you must reverse the poles, and use the positive pole instead of the negative over the body, and your experience must be your guide, as in all other branches of business or modes of treatment. And here comes in again the danger of any or all empiricism, or those using it at all without first having had a proper course of instruction from one who has had already a large amount of experience in treating. Hence, I say, use great care and judgment, both before and after you get this experience for yourself, and always use *similars*, observing when these changes take place in your patient as they progress with their cure — that is, using the positive when it is indicated by a great sensitiveness, and the negative when it is indicated by the opposite state of insensibility to an ordinary current, and never deviating in the least from this unchangeable and fundamental law of polarity or natural equilibrium.

TREATMENT OF FEVERS.

Before leaving this part of my subject, however, I must drop a few hints that will be absolutely necessary with regard to the treatment of fevers, so called, although very improperly. Fever of any kind is not a disease—it is only a symptom of something beyond which produces it. A person no more dies from fever of any kind, even, than another does from pain. And it would be just as correct to say that one person died from pain, as a disease, as to say that another died of fever as a disease.

But we have to use language many times according to custom, in order to be rightly understood, be it

ever so erroneously or ungrammatically applied. There is a deep-seated inflammation always, somewhere, when fever is indicated upon the surface, just as you will always reduce fire in a stove when you find the surface warming up after it was once cold, and the heat upon the surface in each case will be in exact proportion to the amount of heat found to be generated inside. Fever, therefore, is an effect, and not a cause. It is the result of congestion and inflammation, and the different names given to fever arises from the severity, or rather the amount of congestion, found to be upon the part producing a heat upon the surface from the hurried circulation, which is called fever, and the name of bilious, typhoid, or typhus are given to it, according to its type or malignity. The patient, in this condition, is like the furnace with fire kindled within it. This internal fire is consuming, with great rapidity, the entire substance of the body; the capillaries on the surface, which are the tiny chimneys or outlets through the surface of the system, and which give it vitality when open and healthy, are now all closed up, and the surface is dry and glassy, while the pulse, the thermometer to the circulation, indicates the rapid flow of the blood, which has risen from sixty or seventy to one hundred and twenty or one hundred and forty, and the patient is wasting away, or burning up, as it truly may be termed, in a proportionate ratio. Now the man of medicine knows that unless he succeeds in opening those capillaries, and getting up profuse perspiration (which he seldom does with medicine), his patient must run his chance for life. But, in our proper electrical treatment, we

do not say or even think so, for we can stop its rage right here and now, or at any stage we find it, by treating as aforesaid (*similia similibus curanter*). First, then, remember I have said that the fire, the inflammation, the *plus* or positive condition, is internal upon either the lungs, if pneumonia or a lung fever, or upon the stomach and liver, if the more common symptoms of typhoid or typhus form are developed. The perfect simplicity of this system of treatment is such that a mistake need not, cannot even, be made by a proper scientific physician or operator. The internal part or parts therefore being plus, the outside or surface is in the opposite state, or minus. The treatment is with the positive at the feet, or coccyx if as convenient, and the negative used all over the body, causing the current to pass both upward and inward withal from the positive pole to meet the negative upon the surface of the body, and against the ramification of the nerves (in which case I would here observe that the currents always run inward), and by thus doing, the capillaries upon the surface, which are all closed up and producing a dry, glassy skin, are forced open, and a moisture, or a profuse perspiration, is the invariable result. The internal fire or inflammation is thus removed, and the external heat or fever, as it is called, is no more. It departs like the gas-jet when the faucet that supports it is turned down. Now, please remember that this is not a conjecture, but the happy and unvarying experience of sixteen years of careful practice, without the loss of a single patient from the many I have thus treated.

TREATMENT OF CHILLS AND FEVER.

There is one thought more I had better state in this connection, concerning the treatment of chills and fever, which is also treated according to the same law as all other diseases, yet there is a time more favorable than another in which to do it, viz., either an hour or so before the chill is expected, or after it is entirely off and the fever is fairly on, and in each case with the negative pole over the body as for other fevers.

RHEUMATISM, ETC.

Another very important principle is the special benefits of electricity to contract or expand muscle or ligament in certain chronic cases, such as rheumatism, etc., as this disease, whether chronic or acute, is only a contraction of nerve, muscle, or ligament — the positive being the contracting while the negative is the expanding pole wherever applied. For instance, in the cure of rheumatism, you must first ascertain where it is, or on what particular ligament or muscle, as it is very often the result of an injury or sprain upon only one or two tendons at most (and this kind is always the most painful). You must run the current upward or against the ramification of the nerves, having the positive at the feet, in case the contraction is in the legs, and the negative on the spine in the lumbar region, or, as near as you can ascertain, at the root of the injured muscle or nerve where it connects with the spinal column. If in the fingers, wrists, or arms, the positive should be in the hands and the negative between and across the shoulders. Now,

if the student or learner has carefully followed my reasoning, which I have studied to make plain and simple, first by using plain language and common forms of speech, avoiding medical terms as much as possible, he cannot but see the philosophy in, and the correct theory of, my conclusions as to the manner of treatment, which I have proved a thousand times over in my practice, whereas only a short time ago a book was brought to me setting forth a system of electropathic practice for the cure of rheumatism by directly the opposite practice or treatment, which is a most egregious error indeed. I was induced, of course, from this fact to look *over* and *through* the book, and found many other palpable errors, among which was that almost unpardonable, silly one with regard to having the conductors of different lengths in order to get a negative or a positive effect at certain places. This is what I have mentioned once before, and refer to it here again in order to expose, if possible, all undercurrents and hidden or false conclusions, and thereby clear the track entirely of all errors and smoke, whether introduced by professors of great or small calibre, whether in the medical or electrical school—it makes no difference whatever to *me*. My first and last object is *truth*, practical truth; truth that has stood the test of years in the crucible of strong and unrelenting opposition; truth, and nothing else, which I have achieved only by many years of hard study and labor, and which have been years of the most satisfactory experience and close observation.

CONTRACTILE AND EXPANSIVE PRINCIPLES.

I have said nothing as yet about the great benefits resulting from the contractile and expansive principle of electricity, or rather the effect it produces upon nerve and muscle when properly administered. To make the fact more apparent and clear, I will cite two instances of opposite conditions, among many I might mention, as an evident proof of the benefits, and which were the results of my own experience.

Two boys, each about ten years of age, were under my treatment some few years ago. The first a case whose mother, then living on West Logan Square, was under my treatment for other weaknesses, one morning brought her only son with her, saying that he had been to several physicians, who had tried but done nothing for him. The trouble with him was a weakness in his knee- and ankle-joints, which seemed weak and loose. The physician had loaded him down with heavy shoes, part steel and iron, with steel straps each side of the leg, extending up to the body. In this way he could walk better, of course, but they were very heavy, often breaking and getting out of order, and the steel straps, she said, would sometimes wear out a new pair of pants in a week; but, with all of this harness, when it was off he was not a bit better for its use. I examined him carefully, and saw immediately that the difficulty was the result of too rapid growth for the maturity. Both the knee- and ankle-joints were not firm in their place, and would, by a little side pressure, partially slip by each other. The muscle and ligaments wanted both vitalizing and con-

tracting withal to produce the desired result. I commenced the process at once, and in a month, or about a dozen treatments, the thing was accomplished, and he never had any trouble afterwards, or use for the iron shoe or steel straps.

The other was an opposite case or condition entirely. Both legs were badly contracted, and feet drawn up and inward, and had been so, only growing worse, for some years. He had taken a great deal of medicine, and besides all had been under electrical treatment a whole year previous to his being brought to me for treatment, and that even without being benefited—and some applications, he said, had been for an hour at a time. I told the father, under those discouraging circumstances, I wanted nothing to do with the case. He said he had no faith in anything but electricity, and was very anxious to have it tried by a different operator, hearing, as he had, that my system was new and different. I finally commenced the case, more to please the father than anything else, though he willingly paid my full charge for the treatment; but my faith was mere nothing as to a cure. To my surprise, however, and the father's too, he soon began to show signs of improvement in his general health, and also in his limbs. After some ten or a dozen treatments, he could walk round the office by holding on to the wall and balancing himself a little. His father had to carry him in and out when he first came, but soon he improved so that, with crutches to assist him a little, he could walk as fast as his father could in the street.

In the first case mentioned I wanted to contract

ligament, of course, as you must plainly see. This was done by placing the negative pole at the feet and the positive on the spine, where the muscle or ligament needed contracting, or tying up, as it may be termed, and where it must be done, if done at all, and where, by proper treatment, it was done effectually. The second case was of an opposite character entirely, and found to be so too from exact polarity, for I found the Sartorius muscle particularly dormant and contracted, and had to give it special treatment in order to turn the foot out to its place, as well as to lengthen it sufficiently. Will the student or reader please carefully notice here the difference between right and wrong electrical treatment—a matter about which I have spoken so emphatically before—and be profited by it? For, as you see, this boy had been treated a whole year, by a professed electrician, two or three times each week, to no apparent advantage, as his father stated when he brought him to me, just because the doctor was an empiric, and, not understanding his business, did not treat him according to proper electrical laws.

STOPPING OF BLOOD.

I will also just mention the great advantage of this contractile principle of electricity for wounds and bruises of any kind, together with the stoppage of hemorrhages internally and externally, when all other remedies had failed; also the stopping of flooding after confinement, or uterine hemorrhages of ladies from any cause whatever, when properly applied, has been oftentimes truly surprising.

It has also been used with astonishing results in cases of protracted labor, when all pains or natural labor had ceased—even *ergot* having been used without any progress, and nothing left but the common mechanical processes to resort to as inevitable, when, by a gentle application of positive electricity, strong contractions of the womb were produced, and a safe, healthy delivery the almost immediate result.

RESTORATION TO LIFE.

To produce vitality in suspended animation from poisons, drowning, or any cause whatever, we have instances of astonishing results; also in cases of still-born infants. One very remarkable case of this kind only I will mention. A physician in the country was called to attend the delivery of a poor woman; the child was born all right, and apparently healthy, but showed no signs of life—was laid aside as dead. The woman, being poor and destitute, knew not how to procure a burial for her child. The doctor finally told her that if she would give it to him he would take care of it, and would make no charge for his attendance upon her, and would carefully preserve it in spirits, which she might have the privilege of seeing at any time. She consented, and he carried it some three miles (carefully wrapped up) to his home, put away his horse, and took the child into his office, but thought he would first experiment upon it with electricity, when, to his surprise, after only a few minutes, he saw a drawing of some muscle that looked like life. He continued the operation with the battery, and soon it gasped a little, with a little more of muscular motion,

and soon a full breath, and finally full restoration, so that in some two and a half hours after he left the house of the mother with the dead child, he was back again with the same child alive, to the great rejoicing, of course, of the mother; and the child grew to be a man, and is probably alive at this writing.

I have many other cases, well substantiated, of life being restored from drowning, poisoning, taking an over-dose of opium, etc., when the application of electricity seemed to be like bringing life apparently from the dead. In fine, we are only just beginning to learn the great benefits yet to be derived from a greater knowledge of the varied uses of electricity as a vitalizing power for the human system, and the absolute necessity of being prepared to apply it at a moment's warning.

SOMETHING NEW IN THE MANNER OF USING ELECTRICITY.

Before closing the last chapter of this work, I feel I should do great injustice to myself, to the great and grand science I am advocating, and to the general good of the world even, if I finish without calling special attention to a few important facts set forth or heretofore noticed, but have not been made sufficiently clear and distinct. True, indeed, it is but a small work, and the product of only an obscure individual, "*but great oaks from little acorns grow.*"

It will be remembered by those who have carefully read the whole of this work, that I made several claims as being *new*, and the result of *my* discovery, by critically noticing the undivided and inseparable connection between mind and matter brought about

and developed only through the action of this wonderfully mysterious agent, electricity.

While many talk and write about their discoveries in the use of electricity for the cure of disease, I find little or nothing after all, in reading their books or circulars, that I consider an advance or *new*; and I conclude that the community, after reading these works, and even trying the experiment of their treatment, decide with me in the matter — in fact, this is the testimony that comes to me at my office almost daily.

Now it has been a mooted question in my own mind whether it were better to say in this place, and in connection with this matter of instruction, what I really and truly feel it my duty to say, lest I may be set down, as others have been, as advertising myself and practice, and then call upon the people to pay for the advertisement by asking them to buy my book. But this is not at all my object, nor my plan; and I shall ask no one to buy the book except for their own special benefit — for their own enlightenment on this great subject — while abstractly, of course, it will benefit me also. It will have been observed by those who have carefully read this work, that from the beginning I have as far as possible scrupulously avoided making myself prominent, or inviting guests to come to me for treatment before going elsewhere; but rather left them to choose and act for themselves after candidly reading my views, plan, and system. But, as before said, I claim some things — important things — in my work as *new*, entirely *new*, new to myself even when I made the discovery, because they are not in the books, and of course new to men of learn-

ing and science, philosophers, physicians, and physiologists, who readily put into books what they have learned or discovered.

Now, in conclusion, I unhesitatingly repeat that I have something new in the manner of using electricity in order to cure disease quickly and permanently. My best and most convincing evidence of that is what many patients say that come for treatment who had tried several other places or persons, and none used it as I did, and with as favorable results.

Lastly, and perhaps the most important part of all, I add that my manner of *instruction*, as has been stated, is *new* and altogether different. You will observe that I am not confined to *any* one machine in my plan of giving instruction, as some others are, and as described in a new work just published by a lady of our city, where the course or plan of instruction confines the student to one kind of machine only. I use Dr. Kidder's machine, and it is a very good one, and I recommend it to others; but I use three others besides that are good ones. Then I use a direct compound current battery also, without any induction whatever, but has great intensity. This, in some cases of acute inflammation, is by far the best. It cures oftentimes when the induced current does not, and will not.

My mode of instruction then is also *new* and entirely different in this very important particular, viz., any person, after receiving it, can treat with all of these different machines—with one just as well as with another, if the machine itself is a good one. And there are several kinds of very good machines,

while there are several kinds of very poor ones too, I am sorry to say—only made to sell. Then, again, my students know just as well how to use the direct compound current battery (if they choose to use it), when needed, from the same course of instruction, viz., *similia similibus curanter*. That is what I have repeatedly stated before—a plus, where upon a careful examination a plus or positive condition is unmistakably indicated; and a negative or minus where this condition is as plainly indicated, and you will be sure of a satisfactory result.

I have now in brief described the several common modes, as well as principles of electrical treatment, which, if carefully observed, will certainly cure all curable cases or forms of disease. Yet I have other ways of treating which are special, and which I have not room particularly to describe in this small work, but which, to the practical physician, are of great value in some peculiar diseases, such as a transverse treatment, treatments with different metal belts, which very much facilitate the cure in some cases. Then I also use instruments, both internal and external, for males and females in certain cases. This instruction, which is absolutely necessary for a practical physician, can only be given by a short course of lectures, with some practical observation and experience, at my office, or of some thorough proper practical operator.

In concluding this volume, I have, on the following page, added a list both of acute and chronic diseases, alphabetically arranged, which our system of treatment has proved especially successful in curing.

DISEASES CURED BY ELECTROPATHY.

Amaurosis.	Hemorrhage from different causes.
Aphony, loss of voice.	Hysteria, Irritable Spine, etc.
Asthma.	Headache, Sick, Nervous.
Ague Chills, Fever and Ague.	Insanity.
Atrophy, Nervous Consumption.	Inflamed or Sore Eyes.
Atony of the Stomach.	Incontinence of Urine.
Amenorrhœa, Suppressed Menses.	Kidneys, all diseases of.
All Mercurial Diseases.	Liver, torpid state of.
Bites of Poisonous Insects or Animals.	Lungs, Hemorrhage of, Congestion, etc.
Bronchitis.	Lockjaw.
Bladder, Stone or Gravel in.	Liver, Enlargement of.
Consumption in first and second stages.	Leucorrhœa, Fluor Albus, Whites.
Chlorosis, Green Sickness.	Mental Depression.
Concussion of Brain.	Muscular Contraction.
Contraction of Chest, Stricture of Limbs.	Menstruation, Derangement in.
Cholic, from different causes.	Monomania.
Cramps or Spasms, Chronic or Acute.	Milkleg.
Congestive Diseases of all kinds.	Numbness from injuries, or otherwise.
Corea, St. Vitus' Dance.	Neuralgia.
Coldness of Feet and Hands.	Nocturnal Emissions.
Cancers, in certain stages.	Old Sores (indolent ulcers).
Copper-colored Cuticle, or Blotches.	Ozæna in some of its forms.
Catarrh.	Paraplegia.
Diphtheria.	Palsy, Numb or Shaking.
Deformed Limbs straightened.	Paralysis, in whatever part.
Deafness from paralysis of acoustic nerve.	Poisoning.
Dizziness, or Drowsiness.	Palpitation of the Heart.
Dropsy.	Pleurisy.
Diabetes, or Kidney Diseases.	Prostration from various causes.
Diarrhœa.	Prolapsus Uteri, etc.
Dysentery.	Prolapsus Ani, or Piles.
Dyspepsia in all its forms.	Perspiration, Excessive.
Dismenorrhœa, Painful Menstruation.	Perspiration, Suspended.
Difficult Respiration.	Pulmonary Apoplexy.
Enlargement of Joints.	Rush of Blood to the Head.
Ear-ache.	Rheumatism, Acute or Chronic.
Epilepsy, Falling Sickness.	Restlessness.
Fevers of all kinds.	Swelled Tonsils.
Fits from different causes.	Sore Throat, from any cause.
Gastritis, Irritation of Stomach.	Salt Rheum.
Gout.	Scrofula.
Goitre, or Swelled Neck.	Spinal Diseases, Curvature, etc.
Glandular Swellings.	Tumors, Ovarian, etc.
Gravel, or Calculi in the Bladder.	Tremens, Delirium.
Hemiplegia.	Tetanus, or Lockjaw.
	Uterine Misplacements.
	Uterine Weakness of all kinds.
	Weak Eyes, etc.
	White Swellings.

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